ASHRAE

The First 75 Years

Environmental Engineering

1894-1969

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INTRODUCTION

Frank H. Bridgers
President 1970-71
Chairman of ASHRAE's 75th Anniversary Committee 1969-70

The articles contained in this booklet were published in issues of ASHRAE JOURNAL beginning in June 1969. They are a "Pilgrim's Progress" of an engineering society's achievement in developing a group of industries which contributed to man's voyage from earth to the moon. Literally, this bulletin is a record of technological growth accomplished by thousands of dedicated engineers, bonded together for a common purpose—to better the living conditions of humanity.

ASHRAE celebrated its 75th Anniversary at its 1969 Annual Meeting, June 30 to July 2, in Denver, Colorado. Actually, our founder and predecessor, the American Society of Heating & Ventilating Engineers (ASH&VE), was not organized until September 10, 1894 and its first Annual Meeting was held January 22-24, 1895 in New York City. The first President was E. P. Bates of Syracuse, N.Y. The 1969 Annual Meeting at Denver was selected at which to celebrate our Diamond Anniversary as it was the Meeting closest to the date when the Society was formed.

The little group of 75 Charter Members back in 1894 had great faith in their enterprise of having the art of heating and ventilating recognized as an essential, distinctive and highly specialized division of modern engineering. Among his remarks at the first Annual Meeting, President Bates declared: "We are not here as tradespeople. We are not here to force goods on the market, or cry down any other person's goods—nothing of the kind. We are here to talk about theories. We are here to tell of practical results which we may have obtained in experience. You're not here to speak of anybody else in a way that will belittle him or his goods or his practice. Now let us keep on this plane of thought, and it will be an improvement for us all. We are just starting now. Let us start right and hold to the right, and our deliberations here, and our papers, and all that we do, will have a good effect, not only on us, but on the people whom we design to reach."

These pioneers probably did not dream that progress in their profession would be so rapid and that the industry they were serving would become such an important part of the world's economy.

In 1904, the American Society of Refrigerating Engineers (ASRE) was formed and, in 1959, these two great engineering societies merged to form our present ASHRAE.

First President of ASRE was John E. Starr of New York City. At this Society's first meeting, January 4 and 5, 1905, in New York, President Starr stated: "I am not unmindful of the significance, I might almost say the solemnity, of this beginning, for I am fully impressed with the importance of the work already laid out for us and it needs not the eye of a prophet to picture the magnitude of coming events that have cast their shadow before. We have started on a mission similar to that which other great societies in the engineering world are so ably accomplishing, and considering that our particular scope of operation touches on almost every department of human effort. The Grail of the engineer must be first and last—the Truth.

The purpose of a Diamond Anniversary celebration is two-fold. First, to pause and recognize the contributions and progress that have been made by our predecessors and, second, to rededicate ourselves to the high purposes of ASHRAE, namely "to advance the arts and sciences of Heating, Refrigeration, Air Conditioning and Ventilation, and the allied arts and sciences, for the benefit of the general public."

ASHRAE
A Chronicle of Progress
1894-1969

J. H. CANSDALE
Associate Member
Editor, ASHRAE JOURNAL

Dear Sir:
I enclose herewith a check for $1000 received by me last December .... I have endorsed this check to the American Society of Heating and Ventilating Engineers with the stipulation that this gift be applied by them to cooperative research with reference to the Physiological Effect of Atmospheric Ionization and with the hope that such investigation may prove of great benefit to mankind.
Respectfully yours,
Willis H. Carrier

This letter by Dr. Carrier, acknowledged as the "father of air conditioning," reflects the concern with human environment which has dominated the consciousness of ASHRAE members for the past 75 years.

In 1894, the United States was still recovering from the "house-divided" horror of the Civil War and was emerging as a prosperous world leader and empire builder. Four years before, Idaho and Wyoming had been admitted into the Union as the 43rd and 44th states, respectively. Still to be included were Utah, Oklahoma, New Mexico, Arizona, Alaska and Hawaii.

Grover Cleveland was the 24th President and most of the countries of the world were ruled by monarchies. The vast continents of Africa and Asia were largely unexplored and ruled as colonial possessions.

The gross national product — defined as the comprehensive measure of the nation's total annual production of commodities and services — was $13,006,000,000 in 1894 (contrasting with $845,000,000,000 in 1968) and the national debt was approximately $1,263,000,000. (In 1968, the national debt was about $358,240,000,000.)

Under the surface of American life was deep and justified discontent. In 1890, the frontier was officially declared at an end and Americans now had to face up to their problems instead of leaving them for the "great open spaces." The chief forces in conflict were the "rich" — the great railway, steel, oil, and meat barons; the farmers; and the industrial laborers. There was a general belief in a conspiracy on the part of the very rich to ruin the poor and that the federal government was always on the side of the rich. The nation was still in the grip of the financial panic of 1893 and unemployment and labor troubles were universal. Prosperity didn't return until 1896.

Underlying this discontent was a genuine idealism which made each American feel that he must fight for his beliefs and that he must support the "under dog." This idealism propelled the United States into the Spanish American War in 1898 and launched the country as an empire builder. Also, idealism was abetted by the growing number and influence of newspapers and other communications media.

In 1894, the United States was developing rapidly as a world power, as well as a leader abroad. In spite of financial depressions and the agony of Civil War recovery, the

This first of several articles records the founding of ASHRAE by predecessor societies, beginning in 1894, and the historic milestones in ASHRAE's growth to its present membership strength of 25,000. In subsequent issues, through January 1970, authors will explore the Society's role in refrigeration, research, air conditioning, standards, heating and ventilation, publications and, finally, a forecast of ASHRAE's future.

country was embarked on a new era of political, economic and scientific growth.

In 1898, Boston built the first subway in America and, two years later, there were 2500 electric power stations and the first electric trolley cars were in operation. With the invention of the elevator, the apartment house and office skyscraper appeared. The country was changing to a communal rather than personal way of life and the services of scientists and engineers were required to make the needed adjustments. The age-old idea of the "guild" was being reborn: groups of professionals (artists, engineers, scientists, doctors, lawyers, etc.) and master artisans organized in order to share knowledge and to preserve the high principles of their chosen fields.

It was in this ambience, this particular moment of history, that ASHRAE was born. The determination to improve the human environment of mankind was the motivating factor in forming a new organization . . . American Society of Heating and Ventilating Engineers (ASH&VE). . . the first forerunner of today's ASHRAE.

IN THE BEGINNING

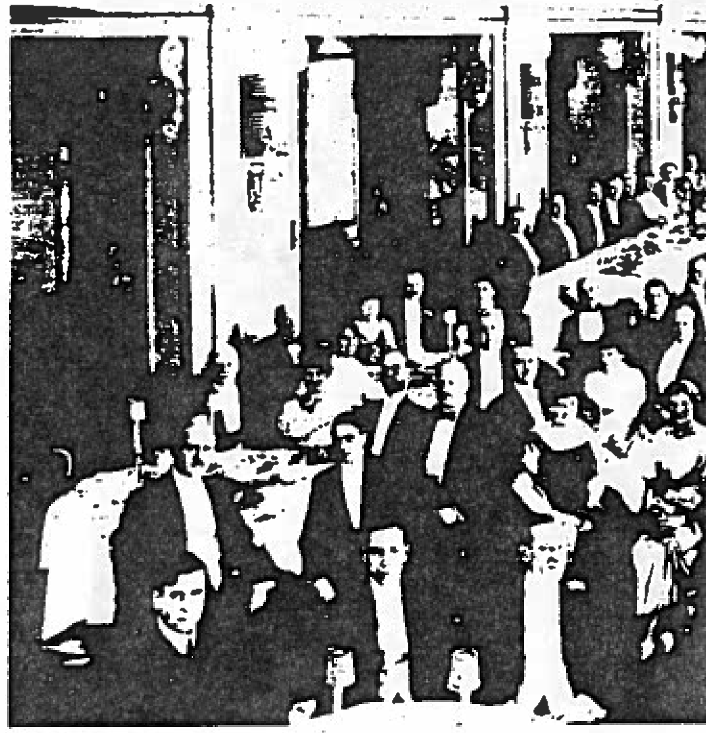
In the summer of 1894, 15 engineers felt that the time was ripe for the formation of an engineering society related to heating and ventilating.

The first regular meeting was called to order at 3:00 p.m., September 10, 1894, at the Broadway Central Hotel, New York City. Roll call established that 75 men had become charter members. Secretary of the new organization, American Society of Heating and Ventilating Engineers (ASH&VE) was L. H. Hart, business manager of the publication, Heating and Ventilation. In its August issue, the magazine stated:

"Attention is hereby directed to the notice of a preliminary meeting for the formation of a Society of Heating and Ventilating Engineers. This movement is one of great importance and should have the hearty support of every engineer who has the welfare of his profession at heart and earnestly seeks to secure its advancement, the objects of the new organization being such as would give to the work of heating and ventilating engineers a prominence and dignity heretofore unknown. It is not intended that the new Society will in any way antagonize the Master Steam and Hot Water Fitters Assn of which the majority of heating and ventilating engineers throughout the country are not members, because the businessmen of which the Master Steam Fitters Assn is largely composed do not appreciate an engineer's feelings in regard to technical matters, giving much less attention to the technical than to the business side by means of which they earn their livelihood."

The September issue of the magazine reported:

"Elsewhere in this issue will be found an account of the formation of the American Society of Heating and Ventilating Engineers, a new organization which promises to advance the arts and sciences of heating and ventilation with great rapidity and with much benefit to humanity. The formation of this society marks the beginning of a distinct era of progress; and decided improvement in the mechanical construction of heating and ventilating



ASH&VE members and their wives are shown at Banquet during Annual Meeting, January 1915

apparatus may be confidently looked for. The encouragement of good fellowship, the diffusion of knowledge on scientific and practical problems, and the establishment of a uniform scale of prices for professional services are objects the attainment of which will be of incalculable benefit not only to members of the society but to the profession at large."

At the fledgling Society's first meeting on September 10, Chairman Fred F. Smith of New York City defined the "objects, advantages, and policy of the organization." Excerpted are:

1. "We are to have an association, so far as I understand it, for the promotion of the arts and sciences connected with heating and ventilation, and to encourage good fellowship among its members.

2. "Our second object is improvement in the mechanical construction of the various appliances used for heating and ventilating.

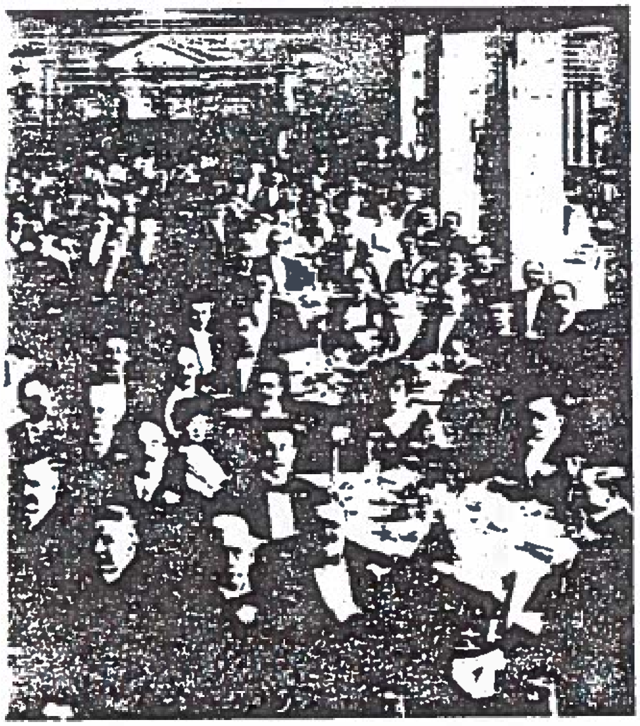
3. "We next come to the maintenance of a high professional standard among heating and ventilating engineers. This does not need explanation. Of course in the way we are working, made up as we are of a society of engineers, our members will be subdivided into many kinds of engineers. There will be the consulting engineer, who is paid for his professional services: and the contracting engineer, who receives pay for his professional services and a profit on his contract; and the manufacturing engineer, who receives pay for his professional services and a profit on all the goods he sells.

4. "To establish a clearly defined minimum standard of heating and ventilating for all classes of buildings.

5. "The reading, discussion, and publication of professional papers, and the interchange of knowledge and experience among its members."

THE FIRST 25 YEARS — 1894-1919

During the next 25 years, ASH&VE's growth and problems paralleled those of the United States which gradually was emerging from its shell of isolationism to become an international power.



The first Annual Meeting of the Society was held January 22-24, 1895, in New York City with first President E. P. Bates of Syracuse, N.Y. presiding. The proceedings of the first Annual Meeting were published in a TRANSACTIONS in 1895. This publication has been issued annually ever since, recording the papers and discussions of each Semiannual and Annual Meeting.

Until January 1897, ASH&VE met once a year. In the summer of that year, the Society held a Semiannual Meeting in New York City and, with few exceptions, had two meetings a year. Membership increased to 220 in 1906 and that year also marked the establishment of the Society's first Chapter, Illinois, with headquarters in Chicago.

Meanwhile, another group of engineers associated with the American Society of Mechanical Engineers (ASME) found little on ASME's program relative to their profession and decided to form an organization devoted to refrigeration. Accordingly, 30 to 40 engineers met in April 1904 and agreed to form the American Society of Refrigerating Engineers (ASRE). Their first meeting was held December 4-5, 1905, with first President John E. Starr wielding the gavel. There were 70 charter members.

In his opening remarks, President Starr declared:

"To define our field in a word, I may say that we claim as our own all that relates to the production of temperatures, below the ordinary, for useful purposes.

"If this be a correct definition, the record of what has been accomplished and what remains to be achieved discloses a sphere of operation worthy of the highest effort.

"The commercial genesis of our art had to do almost entirely with the production of ice. I need not present to you, who are so well acquainted with its history, an array of statistics to show how this branch alone has grown to be one of the greatest industries in this country – and the end is not yet.

"The immediately following developments were in the line of producing low temperatures for the preservation, transportation and marketing of food products, rendering feasible gigantic operations that were before impossible.

"Take a single division of this department – I allude to dairy products of milk, butter, cheese and eggs – and compare it with other industries. Cast up into one sum the total value of our iron trade, our textile fabrics, our lumber and our cotton, add to this all subsidiary manufactures, and the figures will fall below the volume reached by the four items first mentioned; and yet these products in their production, preservation and distribution, could not be handled as they are today without refrigeration.

"Our enormous meat handling and packing industry is absolutely dependent on the efficiency of our work.

"Not alone, however, does the manufacture of ice and the preservation of food call for our best efforts; for while agriculture in its various departments leans heavily on our shoulders to help through the heat of the day, other extensive interests are as close to us.

"Bacchus and Gambrinus rely on us to keep them on their throne.

"Metallurgy, the dean of the arts, has called to us for a helping hand.

"The Oil King demands our best efforts.

"The great textile industries in cotton, silk and the like, with their increasingly severe requirements as to conditions of temperature and moisture, are seeking aid and comfort at our hands.

"My Lady Nicotine is wooing us, pleading for help to preserve her graces and the perfume and texture of her soothing leaf.

"Photography demands great deeds of us.

"The gentle art of perfume production is helpless without us.

"Chemical industries are demanding more from us day by day.

"Our good brothers, the civil engineers, are calling on us to help sink their shafts and build their tunnels.

"Our mining friends look to us to provide a cool place in the Gehenna of their lower levels to recuperate their heat-burdened workmen, and enable them to take out precious ore otherwise not reachable.

"Therapy has already made valuable use of our efforts.

"Sweltering humanity asks us to render more pleasant its places of meeting, and should we desire to indulge our altruistic tendencies, what greater and nobler field in this direction can be offered than the effective amelioration of conditions in the summer-heated, fever-stricken hospital wards, with the possibilities of comforting the sick and the saving of human life?"

Among the accomplishments of both societies were:

1905 - ASRE published its first TRANSACTIONS and employed its first Executive Secretary for the munificent salary of $25 per month. . ."out of which all expenses of that office are to be paid."

1910 - ASH&VE's membership increased to 367.

1912 - ASRE sponsored research at the U.S. Bureau of Standards to Determine the Heat of Fusion of Ice.

1912 - Willis H. Carrier, Charter Member of ASRE, presented his paper on the Psychrometric Chart.

1914 - ASRE began publication of a bi-monthly JOURNAL. Membership totaled 327.

1925-26 – first air-conditioned theater (Rivoli-New York City)

1915 - The first JOURNAL was published by ASH&VE in April 1915.

1915 - ASRE funds resulted in the publication of a reliable ammonia table by the U.S. Bureau of Standards.

1916 - ASH&VE employed its first full-time Executive Secretary.

1917 - ASRE had four chapters: New York, St. Louis, Milwaukee and Chicago.

1918 - Approximately 100 ASH&VE and ASRE members served during World War I.

1919 - ASH&VE established a Research Laboratory in the United States Bureau of Mines, Pittsburgh, Pa.

1919 - 1944

In 1922, ASH&VE published its Heating, Ventilating and Air-Conditioning GUIDE and ten years later ASRE's DATA BOOK made its first appearance.

During their 47 and 37 years of existence, respectively, the GUIDE and the DATA BOOK have had their trials and tribulations, have been praised and criticized, and, because of their sheer weight and bulkiness, have often been a trial for book-toting engineering students. But from their first printings, they have rated the stamp of ultimate "authority." Written by experts, both books have been prized as year-round references by engineers, architects, contractors, government officials and students. Distributed to the membership as part of their dues, these books have also been bought by non-member engineers, by industrial firms and by technical schools and colleges for use as textbooks. Testimonials have been legion:

From a research engineer - "For decades the GUIDE has told our product story authoritatively. Nothing could take its place."

From a consulting engineer - "The GUIDE has been practically a 'bible' for us since it was first published. It is the best reference work for Heating, Ventilation and Air Conditioning that I know and it is in constant use by the engineers in our office."

From a college president - "By far the best reference book in its field - for engineers, architects and users of equipment." (GUIDE)

From a professor of mechanical engineering - "In spite of the size, bulk, weight, and cost, I have specified that the GUIDE will be used in next semester's classes."

From an operating engineer - "I received my copy of the Refrigerating DATA BOOK and I must say that I am highly pleased with it. It is the best book I ever came across covering the subject of refrigeration. I may also say that you may use my name as a very highly satisfied owner of the DATA BOOK."

From an air-conditioning company - "We want to take the opportunity to compliment you on the completeness of this book. It is a splendid piece of work - the only one we know of that has such a world of information. We have repeated our order and our New York office can also make use of some of these books." (DATA BOOK)

From a practical man - "Haven't found one page that was not worth the price of the volume." (DATA BOOK)

From a consulting engineer - "I cannot forbear writing to congratulate you and the various authors on this exceedingly valuable and interesting and helpful edition." (DATA BOOK)

1922 - ASH&VE's first Canadian Chapter, Toronto, was established. This Society now has 32 chapters.

1928 - ASH&VE honors Benjamin Franklin as Patron Saint of the Society.

1930 - ASH&VE sponsors first International Heating and Air-Conditioning Exposition.

1930 - ASH&VE creates F. Paul Anderson Medal and, two years later, makes first award to Dr. Willis H. Carrier.

1933 - Publication by ASRE of a Mechanical Refrigeration Safety Code which is still in existence in 1969.

"The application of this Code is intended to insure the safe design, construction, installation, operation, and inspection of every *refrigeration system* employing a fluid which is vaporized and is normally liquefied in its refrigeration cycle. . . .

"This Code is intended to provide reasonable safeguards to life, limb, health, and property; to correct certain practices which are inconsistent with safety: and to prescribe standards of safety which will properly influence future progress and developments in *refrigerating systems*."

1938 - ASH&VE membership passes 3000.

1941 - ASH&VE requested to conduct a physiological research project for the U.S. Navy so that fighting men in the South Pacific could better withstand high temperature and excessive humidity.

1944 - Members of ASH&VE and ASRE in World War II total more than 500.

1944 - 1969

1945 - ASRE has 20 Chapters.

1946 - ASH&VE bought permanent quarters in Cleveland. Ohio for its Research Laboratory, staffed by Society personnel. ASH&VE was the only engineering society in the U.S. to have its own private research laboratory.

1954 - ASH&VE changed its identity to the American Society of Heating and Air-Conditioning Engineers Inc, (ASHAE), incorporated December 8.

1959 - ASHAE and ASRE merged into the American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc, (ASHRAE), January 29.

1959 - ASHRAE JOURNAL makes its debut as official monthly publication of the Society.

1961 - ASHRAE headquarters located in United Engineering Center, New York City, with approximately 40 staff members.

1961 - ASHRAE disbands Cleveland Research Laboratory and invests funds in cooperative research projects.

1961 - The ASHAE GUIDE and the ASRE DATA BOOK merged into the first ASHRAE GUIDE AND DATA BOOK, currently a three-volume series – Equipment. Systems, and Applications.

1967 - HANDBOOK OF FUNDAMENTALS – a basic engineering textbook – supplements ASHRAE GUIDE AND DATA BOOK series.

1967 - Andrew T. Boggs III succeeds Robert C. Cross as Executive Secretary.

1968 - The Society has 18 overseas Affiliates.

1968 - ASHRAE charters its 105th chapter in the U.S. and Canada.

1969 - ASHRAE membership approaches 25,000.

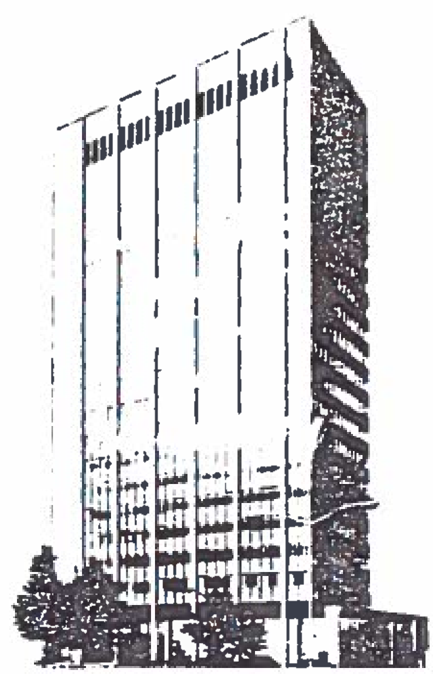
1969 - ASHRAE conducts 18 research projects at 13 cooperative institutions, the majority of them being colleges. Budget, including direct expenditures, administration and overhead, is $340,000.

1969 - ASHRAE sponsors 19th International Heating and Air-Conditioning Exposition, held in Chicago.

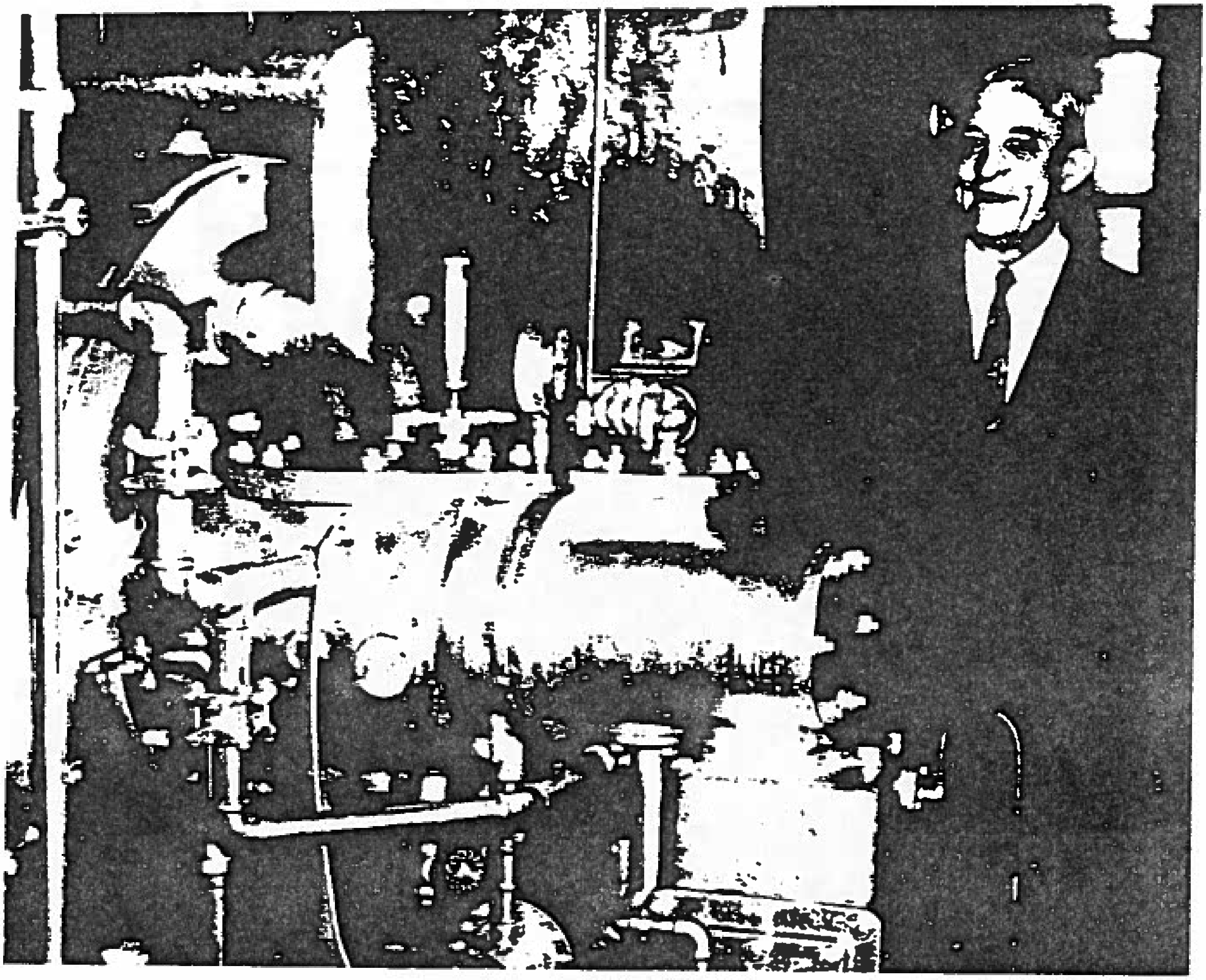
1969 - JUNE - ASHRAE celebrates 75th anniversary.

WHERE NOW?

The foregoing barely outlines the history of an organization which piloted the development of the heating, refrigeration, air-conditioning and ventilation industries. In the relatively brief period of 75 years, the world has plummeted from exploration of new land frontiers to the exploration of outer space. Our next frontier may be the moon. The control of man's environment became more of a reality in these past 75 years than in all the previous centuries.



ASHRAE Headquarters at United Engineering Center



Dr. Willis H. Carrier with centrifugal refrigeration machine installed at Onondaga Pottery Co. in 1923

Before the present age of the computer, mankind relied upon cumulative knowledge and the genius of men devoted to the pursuit of individual dreams and a better way of living.

ASHRAE's countless thousands of members included many men of genius and still does. The problems of our age are no less than those that confronted our founding fathers. The danger of an exploding hydrogen bomb is no greater than the effects of air pollution.

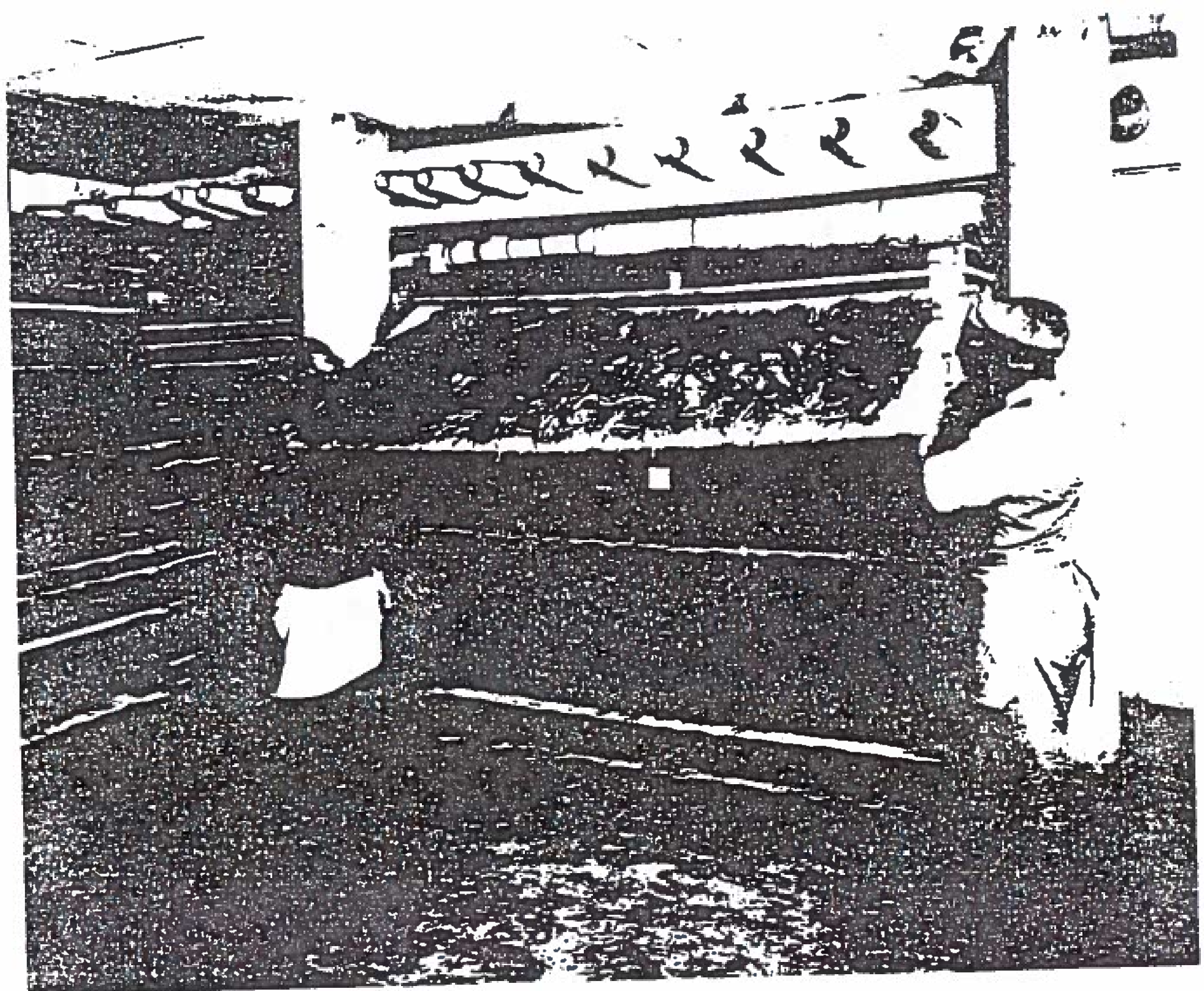
The objects which prompted 75 men to found ASHRAE are still dominant: to improve the control of man's environment; to guide promising students into the field of engineering; to ensure that each engineering student receives the best education possible; to enlist qualified engineers into the Society's membership; and that each practicing engineer "should recognize . . . a set of dynamic principles guiding his conduct and way of life." (from Canons of Ethics for Engineers).

Today, the focus on education, manpower development and professional ethics are just as relevant as 75 years ago. In 1942, Dr. W. H. Carrier stated:

"The student is expected to learn more and more in a given time and the courses must be made 'easy' so he can accomplish the work laid out in the curriculum. To obtain high or even passing marks, he must memorize extensively: he cannot take time to think. The main purposes of an engineering education — a thorough understanding of principles and training in the use of the mental 'tools' of the profession — are thus defeated. Training in thinking is far more important than the mere acquisition of factual knowledge. Employers want graduates trained in logical thinking, in habits of thoroughness, and in the scientific method of approach.

"In engineering education, the aim should be to have no fact or theory accepted until it is first thoroughly understood. Memorizing without thorough understanding does not develop the habit of mind that is so necessary in later life to the successful engineer. On the contrary, it leads to a habit of taking things for granted, and often to a feeling of mental helplessness and inferiority fatal to mental progress in later life.

"The engineer who advances the boundaries of his profession must have curiosity and an inquiring mind. These natural mental attributes should not be deadened or stultified in the process of technical education, but should be stimulated and developed. Teaching, so far as possible, should be through guidance rather than through enforced



1920-24—ejector dryer and moisture regain system of air circulation as applied to a tobacco processing room

assistance. The inductive method should precede the classical, and commonly overdone, deductive method."

Seventeen years later, in the second issue of ASHRAE JOURNAL, ASHRAE Member John Engalitcheff, Jr., wrote:

"In college I took mechanical engineering on the firm conviction of my family that I was mechanically inclined. . . .

"After graduation, I got a $26-a-week job with a small air-conditioning firm for the simple reason that it was the only job I could get in the depression of 1930.

"For two years I kept that job because I had to. This 'jail sentence' became a blessing, because by the end of that two years, I was so fascinated with the industry that I had no choice but to stay in. . . .

"What would I do now if I were 21, just out of college, and a graduate of mechanical engineering? Were I to start over, would it again be in the air-conditioning and refrigeration field?. . .

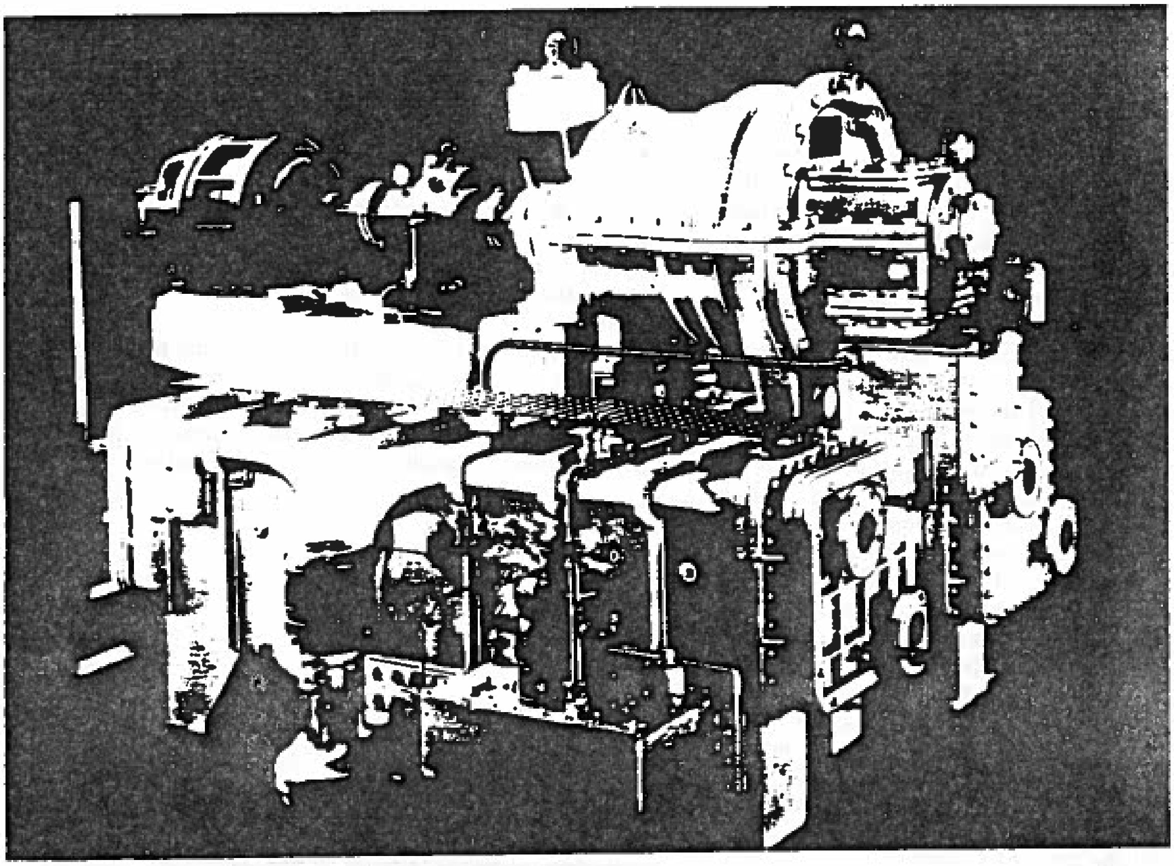
"If I began my life again, I definitely would do the same thing. There is no doubt in my mind that with an ME degree, I would immediately enter the refrigeration field.

'Why?

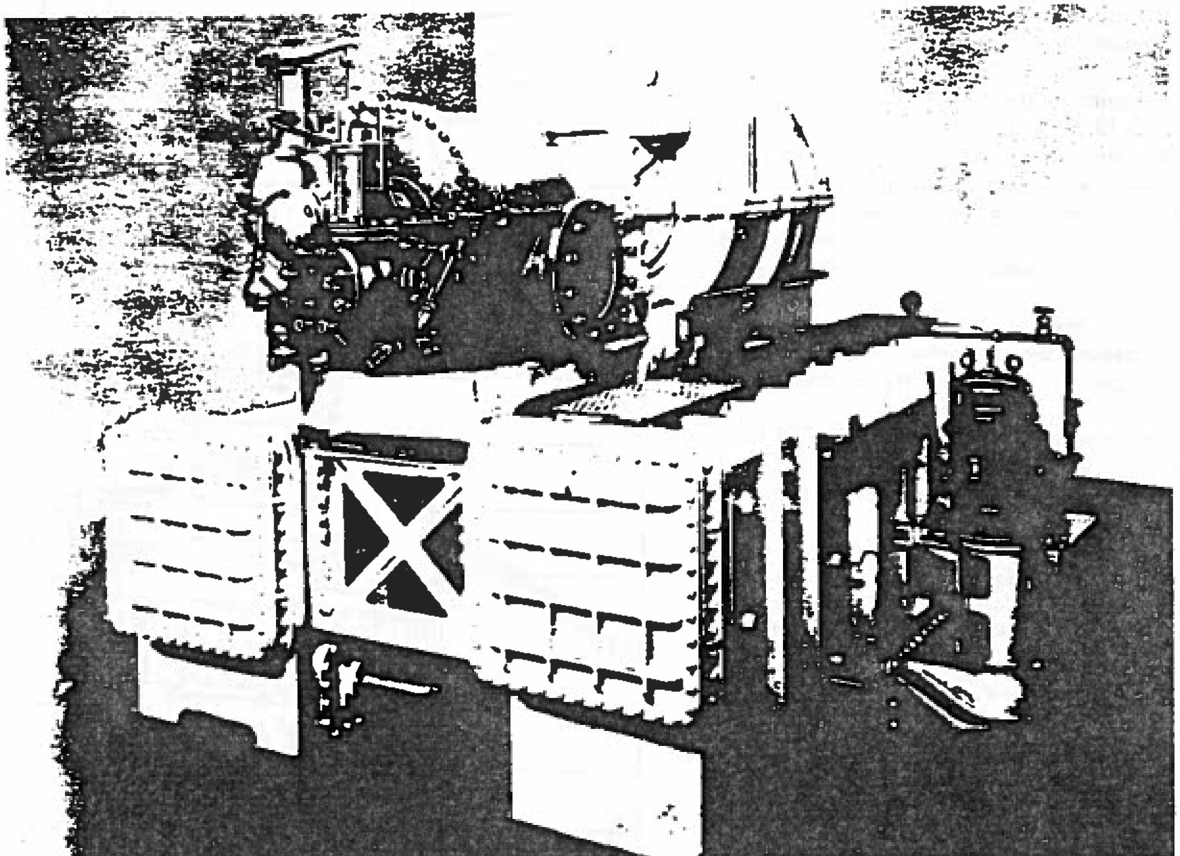
"Well, first let's take a look at the air-conditioning and refrigeration field on a statistical basis. The industry is in its adolescence with tremendous potential for development and growth. I heard one statement made that the market is only 1/6 saturated. And this is probably an overstatement. With conservative estimates of the industry's present volume of $2 billion, and with a total employment of over 200,000 people, you can get a good appreciation of future opportunities.

"In recent years, refrigeration has become an accepted necessity in the packaging and distributing of foodstuffs. Furthermore, in other industries the heating and cooling of materials is becoming progressively more important to manufacturing. . . .And as we move into space we find tremendous new problems in heat transfer for both men and materials.

"Air conditioning is also in its early stages. We can all see the daily progress made here – whether in living, working, transportation, or recreational areas. Someday, they will *all* be air conditioned. Cooled when they are too hot; warmed when they are too cold. And the cooling, warming, circulating, filtering, dehumidifying and humidifying are only part of the story. In many specialized industries, we remove microscopic dusts and pollens, remove odors, and maintain optimum gaseous contents.



A 1930 centrifugal refrigeration machine



Early model of a centrifugal refrigeration machine. Note the cast iron rectangular evaporator and condenser vessels

"There is no excitement in work like that of being in on something new. Every day we in the industry realize more and more possibilities. And it is you, the young man finishing college today, who is going to push even further into the unknown."

In 1967, eight years later, then President William L. McGrath, stated:

"Our industry has reached the state where annual volume can be estimated in excess of $5 billion* if you include all the machinery and the systems the engineers in this Society are likely to deal with, along with the installation and operating costs. Almost all segments seem to be on a sustained uptrend. As a whole, air-conditioning, cooling capacity sold annually has more than doubled in the past five years. Annual sales of central residential air-conditioning systems have doubled in just 3.8 years. Room air conditioner sales are increasing at a somewhat similar, if less stable, rate and of course automobile air conditioning acceptance has grown four-fold since 1960.

"Looking ahead 10 years, I think we can anticipate many startling things. You probably are well aware of the favorable economic predictions that may influence our industry. The gross national product of this country has increased in recent years at a rate something over 4% per year and it is predicted that some day in 1972 the GNP in actual 1972 dollars will hit the figure of $1 trillion. . . .

"The population will continue to increase, rising another 23% in the next 10 years to nearly 250 million. Even more significant is the growth in numbers of people with relatively high disposable income. It is estimated that in the next 10 years, households in the $10,000 and up income group will increase from approximately 10 or 11 million to somewhere near 35 to 40 million. As income grows, and also as buyers become more sophisticated, more of them will insist on properly air-conditioned homes, automobiles and factories, and will have the means to create the demand for an astonishing array of food products which will depend upon refrigeration for preparation, distribution or marketing."

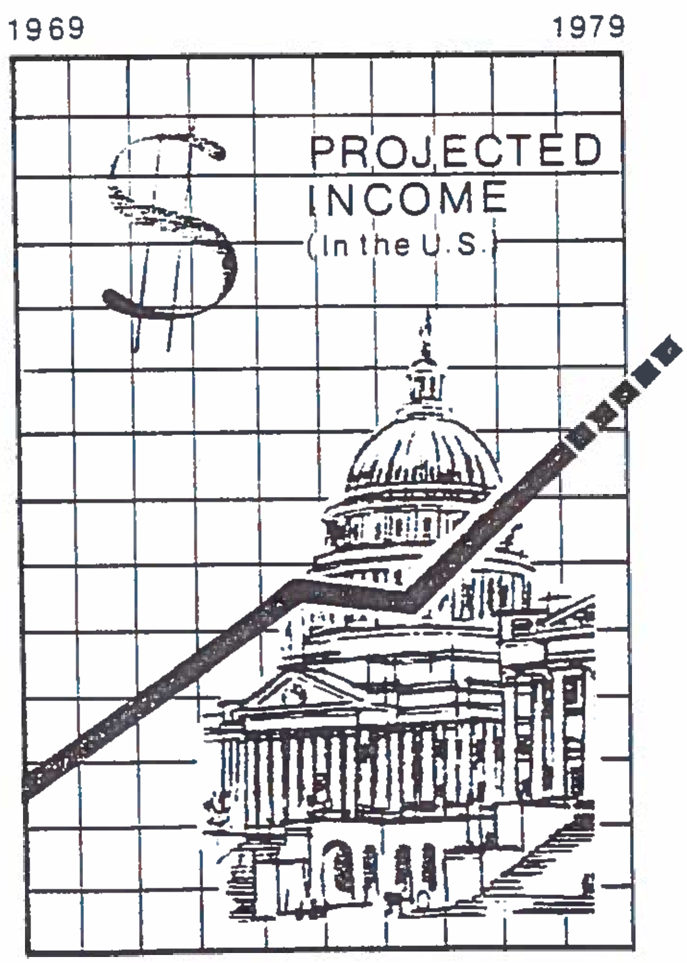
Following these remarks, Mr. McGrath emphasized the urgency of increasing the employment of engineers to keep pace with the growth of the industries represented by ASHRAE. He said:

"Our Society is unique in that it provides the technological support for a unique industry. It would be hard to find a parallel for the dynamic posture of ASHRAE in relation to the industry it serves.

"We must be involved in what the future has in store. We must keep up with the times technologically. We must be masters of the sciences that relate to this industry. This means vigilance, detecting trends in the needs of the future and readiness to pick up the challenge represented by a need for research or a need for information to execute our work diligently and expeditiously. In the next 10 years there may be drastic changes. Air pollution both inside and outside is destined to become an important activity. Also, there will be demands for revolutionary improvements in the quality of environmental control."

Technology has made great gains since 1894, but the ideologies, skills and drives which motivated 75 men to do something about the world in which they lived and worked, fostered those technologies and will continue to do so in the future.

ASHRAE, and its impact on peoples and products, is the sum total of the efforts of its members in promoting their professions, their careers, the striving for a better life, their compulsion to leave their marks in history, and the natural tendency to guide others in their footpaths.



For 1969, annual volume was estimated at $10 billion.

The History of Refrigeration; 220 Years of Mechanical and Chemical Cold: 1748-1968

WILLIS R. WOOLRICH
ASHRAE Fellow and Life Member

EARLY EXPERIMENTAL COLD 1748-1844

THE pre-mechanical refrigeration calendar of invention and discovery for the production, utilization and storing of cold extends back into history to the use of mountain snows, pond and lake ice, chemical mixture cooling to form freezing baths, and the manufacture of ice by evaporative and radiation cooling of water on clear nights.

Some verse lines from the "She King" in Chinese poetry, 1100 B.C., reflect the community interest in the ice harvest in the second millennium:

> "In the days of the second month, they hew out the ice with harmonious blows.
> And in the third month, they convey it to the ice houses
> Which they open in those of the fourth, early in the morning,
> Having offered in sacrifice a lamb with scallions."

W.R. Woolrich, Dean Emeritus of the College of Engineering and Professor Emeritus of Mechanical Engineering, University of Texas, Austin, is currently a consulting engineer in refrigeration and cryogenic refrigeration, Austin, Tex. He holds two U.S. patents on freezers and is the author of The Man Who Created Cold, a history of refrigeration and its development, 1967. He was also editor-in-chief, Air Conditioning, Refrigerating DATA BOOK *1956-57, and author of Volume I – Fundamentals and Volume II – Applications, 4th edition, Handbook of Refrigerating Engineering 1965-66.*

Complementing the utilization of mountain snow, and pond and lake ice in warm climates was the production of cold by producing a bath solution of "frigoric" mixtures such as saltpeter mixed with water and ice.

By the 18th century, some 10 or 15 similar mixtures were known to lower the temperature. Some mixtures, such as calcium chloride and snow, which made possible a temperature down to –27 F (–32.8 C) were introduced for commercial use. Chemical mixture freezing machines were introduced in Great Britain for the production of low temperatures, but by the time these inventions were available for exploitation, mechanical ice making processes made the chemical mixture methods for freezing non-competitive except for some bath processes like ice cream making which used a mixture of common salt and ice.

EVAPORATIVE AND INTERSTELLAR COOLING AND FREEZING

In both Egypt and India, the evaporative cooling process supported by radiation to clear skies at night furnished ice for the royal tables as early as 500 B.C. Protagoras of Greece wrote of the early Egyptians: "They expose the evaporative earthen ewers on the highest part of the house and two slaves are kept sprinkling their porous pitchers with water the whole night. By morning the water has become so cold it does not require snow to cool it to ice temperature."

THE BEGINNING OF MAN-MADE REFRIGERATION

In 1748, William Cullen of the University of Glasgow in Scotland made the earliest demonstration of the man-made production of cold when he evaporated ether in a partial vacuum. In 1805, Oliver Evans of Philadelphia, Pa., proposed a closed cycle of compression refrigeration, and in 1844 John Gorrie of Apalachicola, Fla., described in the Apalachicola Commercial Advertiser his new machine for the ice and air-cooling needs of his hospital.

Many of the difficulties of obtaining punctual deliveries of the ice to the Gulf ports from the Boston lakes could be laid to storms around the Florida coast. There was, however, a developing quarrel on most transactions as between the North and South businessmen, including bank credits and prices of delivered ice. The retail price of Boston lake ice, when available at the Gulf ports from Apalachicola, Fla., to Brownsville, Tex., was 10 cents/lb. It was the increasing failure of steamship deliveries of ice that had caused Dr. John Gorrie to invent a machine ice maker to insure his hospital fever patients that ice would always be available at Apalachicola.

These early developments resulted in the invention and operation of refrigeration machines in Texas and Louisiana. Since there was no southern technical press, their accomplishments were reported only in the daily newspapers.

The economic problems of the Australians in transporting surplus meats and other perishable foodstuffs were not unlike those of the stockmen of Texas and all of the other semi-tropical Gulf states. Both Australia and Texas, and the Gulf Southwest, had to solve the problem of transporting surplus foodstuffs to Great Britain and Western Europe where there were insufficient supplies of perishable products, especially fresh meat. To move by water highly perishable meats from the 30th parallel south of the equator (the location of Australia) to London, Paris or Amsterdam, however, involved much more difficult conservation problems than to carry a shipload of beef or mutton from Galveston, Tex., to those same consumer centers, near the northern 50th parallel to Europe.

The accomplishments of the Australians in solving their transport problems at so early a date were of greater scientific significance than those of the Americans, since they succeeded with a much more difficult task and accomplished their end just a few months later. In their shipping trials, they put first-grade frozen meats, by mechanical refrigeration, on the tables of Europe soon after the Americans invaded the French and English market with ice-packed cold storage beef.

The third area to promote the production of low temperatures, the United Kingdom and Western Europe, followed immediately with the invention and manufacture of commercial refrigerating machines and systems. Great Britain, France and Germany with their wealth and manufacturing capacity soon began to manufacture refrigeration equipment for use on both land and sea.

The calendar of mechanical and chemical refrigeration invention began in 1748 in Glasgow and Edinburgh, Scotland. The guiding genius who inspired the discoveries and inventions was Dr. William Cullen who, as a medical school physician, was charged to teach physics and chemistry in the hospital quarters. His subsequent associate at the two universities which he served was Joseph Black who lectured on the latent heat of fusion and evaporation and also "fixed air" (later identified as carbon dioxide).

Edward Nairne was a laboratory assistant of Dr. Cullen's at Edinburgh, who gave most of his time in laboratory research on adsorption studies.

Subsequently employed by the University of Edinburgh to continue Dr. Cullen's work in 1810 was Sir John Leslie who was born in 1766 in Largs, Scotland. The chair opening in 1810 at Edinburgh was in mathematics. Sir John Leslie had published in 1804, his Experimental Inquiry into the Nature of Heat, which earned for him the Rumford medal of the Royal Society of London.

Leslie's application for the position at Edinburgh caused much controversy. The governing body was made up of professors of theology, the classics and the humanities. They opposed any further investigations into the nature of heat since, they were convinced, any investigator of heat must have subversive alliance with the prince of heat, the historical devil. They admonished Sir John that, if elected, he should adhere to *pure* mathematics in his researches. Subsequently, however, after election Professor Sir John Leslie developed a system of adsorbent cooling to a very low temperature using sulfuric acid and water as the refrigeration medium.

In this span of years during which the Scots had made significant progress in finding means of producing freezing temperatures, Oliver Evans of Philadelphia, inventor of the Cornish boiler, had published a thermodynamic text under the title An Abortion of a Steam Engineers Guide, in which he described in some detail the possible production of mechanical cold by the compression and expansion of volatile liquids in closed cycle.

Evans had developed the Cornish boiler with the assistance of Richard Trevithick of Cornwall, England. The name Cornish was apparently given the unique boiler design in recognition of the help Trevithick had given in their interchange of correspondence. The Cornishman Trevithick had informed Evans by correspondence, of some of the unique features of the boilers used in the mines, car-unloading and screening plants or "tipples" and the pumping stations of Cornwall coal and metal mines.

The next American to contribute a practical solution to the mechanical production of cold was Jacob Perkins of New England. Perkins was also a conferee of Oliver Evans. He had paid a visit to Philadelphia to exchange ideas with Evans on a practical compression system to produce ice.

But Perkins was also an engraver of coins and metal parts and was successful in obtaining a British coin engraving contract that required his taking up residence in England. On his arrival in England he conferred with Richard Trevithick who was then employed as a consultant to J. and E. Hall Ltd on refrigeration designs. Thus the compressors in the making had then the benefit of the creative ideas of both Evans and Trevithick by Perkins the legal inventor.

Soon after Trevithick died (1833) Jacob Perkins obtained his British patent, No. 6662 (1834), on a closed cycle volatile liquid compressor and condenser. Perkins subsequently employed John Hague of East London to build and test his ice making equipment at the site of the John Hague machine shops on the Thames River. The Perkins equipment worked adequately to make ice and was highly publicized in Europe as the probable solution to the problem of commercial manufacture of man-made ice.

While the Perkins machine did make ice experimentally, apparently the inventor was too greatly occupied in the execution of his British engraving contract to stop and raise the necessary capital to promote his invention. It was later

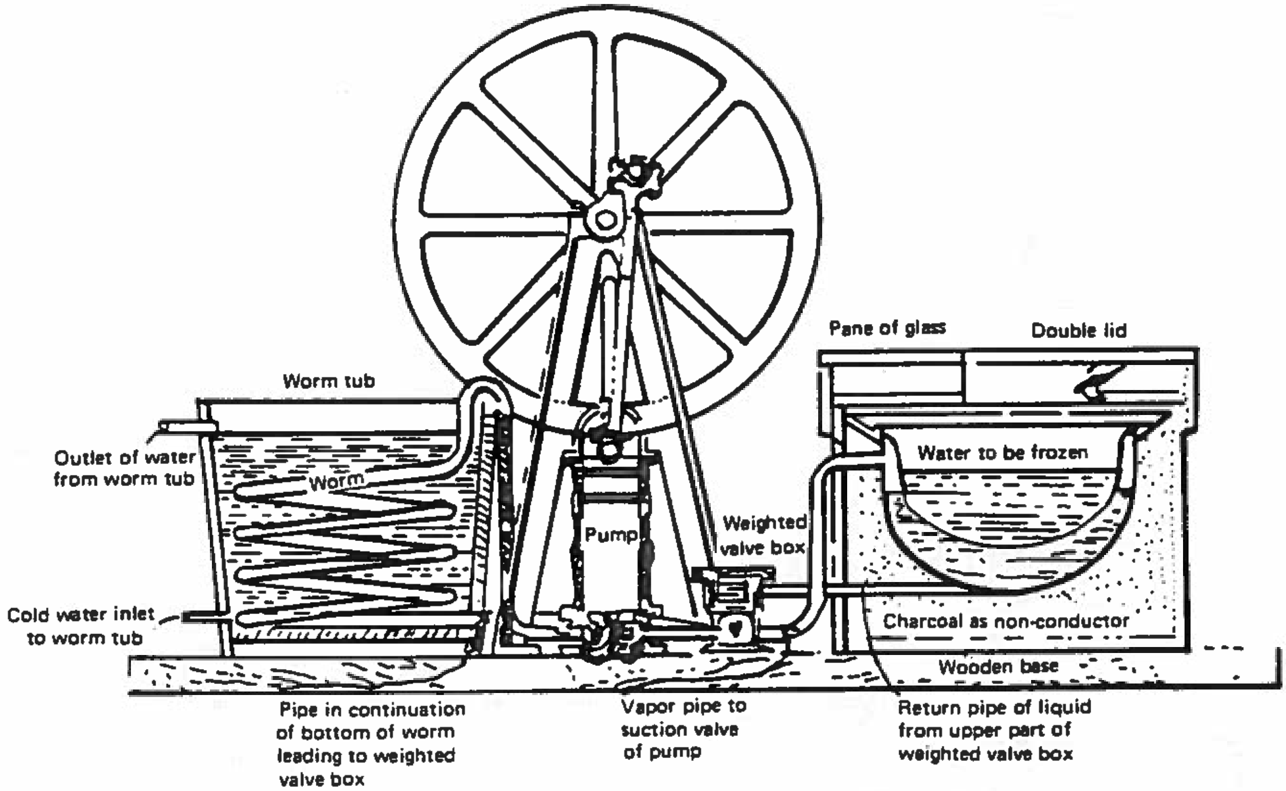


Fig. 1 Ice machine designed by Jacob Perkins, an American, about 1834. The print is from a drawing in the Journal of Arts, published in 1882

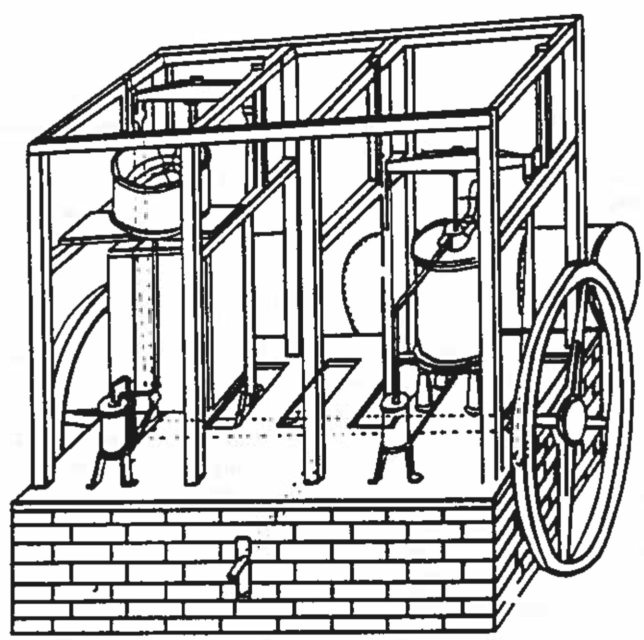


Fig. 2 John Gorrie's ice machine, one of which shipped to England, became the model on which many other similar machines were built. Gorrie failed, however, to reap much benefit from his invention

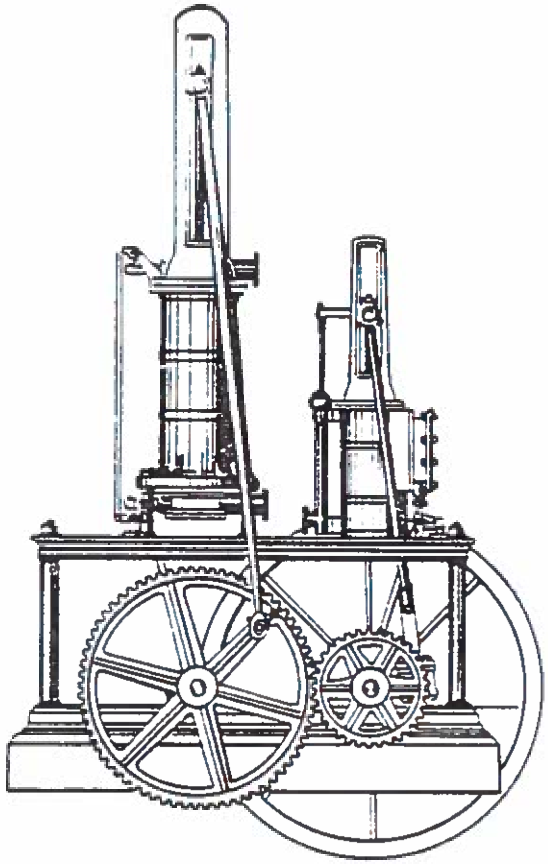


Fig. 3 This ether compression machine was built about 1856 by James Harrison of Australia. A machine of his design was used for many years in an Australian brewery the first application of its kind

copied as a workable model by other refrigeration inventors even outside of the British Isles.

THE COMMERCIAL MANUFACTURE OF COLD WHERE THE 'GODS' SUPPLY NO ICE
1844-1865-1885

As previously mentioned, it was in 1844 that Dr. John Gorrie (1803-1855), director of the U.S. Marine Hospital at Apalachicola, Fla., described his new refrigeration machine in the Apalachicola Commercial Advertiser. In 1851 he was granted U.S. Patent No. 8080. This was the first commercial machine in the world built and used for refrigeration and air conditioning. Gorrie's machine received international recognition and acceptance. He had spent considerable time in New Orleans getting the machine shops of that region to build his machine and equipment for his system and the patent was issued to John Gorrie, New Orleans, La.

Gorrie graduated from the College of Physicians and Surgeons of the Western District of the State of New York, Fairfield, in 1827. After an internship he settled in Apalachicola in 1833, apparently upon the urging of his close friend and counselor John C. Calhoun, who was greatly interested in the hospitalization of United States sailors afflicted with malaria and yellow fever. Dr. Gorrie took a contract with the United States to care for the sick and injured sailors in the marine hospital that had been established at Apalachicola.

From 1834 to 1838 Gorrie also served as postmaster and as chairman of the city council of Apalachicola. Later he was named city treasurer and given a commission to supervise draining the swamps around Apalachicola, and expanding the facilities of the marine hospital.

Gorrie's researches on the production of cold by compressing atmospheric air in an open-cycle system made it possible for him to write with some authority, but he preferred to use the pen name "Jenner" rather than to quote any of his own findings.

Jenner wrote in the Apalachicola Advertiser that "if air were highly compressed, it would heat up by the energy of the compression. If this compressed air were run through metal pipes cooled with water, and if this air cooled to the water temperature was expanded down to atmospheric pressure again, very low temperatures could be obtained, even low enough to freeze water in pans in a refrigerator box.

"There are advantages to be derived from the generation of cool air within any building and this is equally applicable to ships as well. It might enable the hardy mariner to better serve mankind, he who contributes so much to our wealth and pleasure by transporting for us, from shore to shore, the rich production of the tropics—as animals when divested of life, and fruits which may be preserved entirely with all of their juices in a low temperature (atmosphere). This principle of producing and maintaining cold might be made instrumental in preserving organic matter for an indefinite time and thus become an accessory to the extension of commerce."

Gorrie's anticipation of the ridicule the making of ice would engender was well founded. The New York Globe chided, "There is a crank down in Apalachicola, Florida, that thinks he can make ice by his machine as good as God Almighty." But his strategy to attract men of sound judgment served the physician-inventor well. His series of articles came to the attention of a Boston financier who made funds available to launch his full-scale refrigeration and air-cooling plant at the marine hospital and placed his name in history as the father of both air conditioning and commercial ice manufacture.

A statue erected at Apalachicola, Florida, gives this citation:

"Dr. John Gorrie, born at Charleston, S.C., October 3, 1803 died at Apalachicola, June 29, 1855.

"Inventor of ice machine and refrigeration as described in his patent U.S. No. 8080, August 22, 1850.

"A pioneer who devoted his talents to the benefit of Mankind."

In 1914, a State of Florida statue was erected in his honor in Statuary Hall in the Capitol of the United States as one of its two most distinguished pioneer citizens of that state, in recognition of his contributions to refrigeration and air cooling.

Four years later, in 1849, Alexander Catlin Twining of New Haven, Conn., a son of the treasurer and steward of Yale University, a graduate engineer of West Point and Yale, filed a caveat in Washington and applied for a patent in England on a refrigerating compressor system, using ether as the refrigerant. He received a British patent in 1850 and his U.S. Patent No. 10,221 on November 8, 1853.

The National Intelligencer in Washington, D.C., of October 16, 1856 reported: "An (Twining) ice machine has been completed at Cuyahoga Ice Works, Cleveland, Ohio, which is capable of producing one ton of solid crystal ice in twenty hours. A trial run has recently been made while the mercury stood at 80 degrees and the estimated expense of manufacturing ice by the Twining machine was $5.00 per ton or one-fourth cent per pound."

The caveat date of the invention of Alexander Catlin Twining with the subsequent published record on October 16, 1856, establishes it as the first compression machine in the world to make commercial ice by the vapor compression system.

It had been just five years prior to this commercial production of ice at Cuyahoga Ice Manufactury, Cleveland, Ohio, that Dr. John Gorrie of Apalachicola, Fla. had made ice and refrigerated air by using compressed air in an open cycle for the hospital of which he was director.

Twining and Gorrie have been honored by ASHRAE with memorial plaques displayed permanently at the New York headquarters.

One hundred years after the discoveries in the production of cold by the Scot, Dr. William Cullen of Glasgow University, James Harrison, a Scottish journalist born in Renton, Dombartonshire, Scotland, who had built up an enterprising newspaper at Geelong, Australia, became convinced that the economic salvation of Australia lay in the marketing of her available millions of pounds of meat to the temperate habitats of millions of Europeans who lived on the other side of a thermally hostile equatorial region where water and air temperatures well above 100 F prevailed most hours of each day.

When Harrison entered the refrigeration field, the only promising machines for producing cold were those of Gorrie and Twining. A Siemens European report on the Gorrie invention had not been unqualifiedly encouraging. After six years' operation the Twining's investment at Cleveland had failed in competition with Great Lakes natural ice, but it had made mechanical ice at an attractive price per pound. Harrison knew that before any machine could be used on the hazardous journey over the tropical sea it would be advisable to develop a refrigeration compressor that would produce cold for industrial uses in a hot climate with unfailing reliability.

As early as 1851 he began to study the possibility of making ice mechanically. He reviewed the work of Perkins, Gorrie and Twining and then built a small compressor at Geelong on the Barwan River using sulfuric ether as the refrigerant, much like the Twining design.

The Harrison machine was launched commercially with the building of two units at the shops of P.N. Russell & Co, Sydney, Australia, in 1859, and of two others in the plant of Siebe & Gorman of London in 1861. One of the two machines built by Russell was installed in 1860 in a brewery in Victoria, Australia and operated for many years. This installation evidently pre-dates all other brewery mechanical refrigeration plants in the world. The other machine was installed in Melbourne in 1859; of 10-ton ice-making capacity, it operated there for many years.

Harrison maintained his interest in freezing Australian meat for export. He realized it would be necessary to give the meat a deep freeze to withstand two or three months of tropical temperature. At this stage, his friend Thomas Mort came into the picture, and with Mort's wealth and the help of engineer Nicolle, the problem of delivering beef and mutton across the equator from Melbourne and Sydney to Europe was solved.

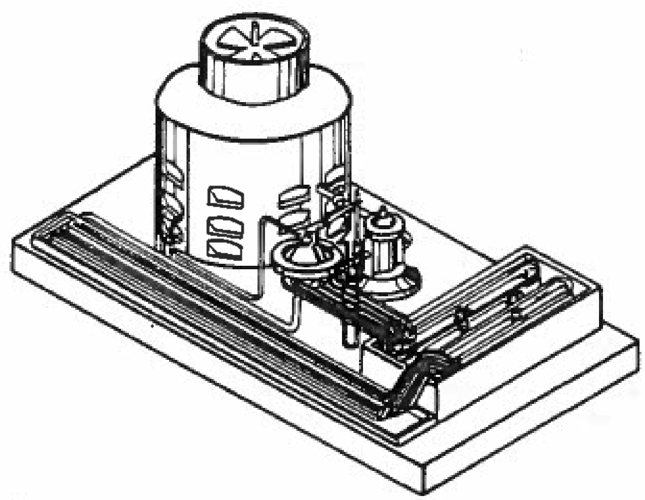


Fig. 4 A refrigeration machine developed on the west coast of the United States in the 1870's by John Beath and Samuel Martin

Harrison lived to see his dream of Australian beef and mutton on European tables come true, but it was Mort, Nicolle and European financiers who made it possible to complete the job. Both Harrison and Mort lost a fortune in the initial trials.

In the annals of technology Harrison must be recognized as the first man in history to successfully operate a mechanical refrigeration plant for a brewery. But it was Australia's dire need to distribute its meat resources to world markets that had sparked his enthusiasm and determination to solve the meat refrigeration riddle.

A striking illustration of the age-old truism that "human necessity is the mother of invention" was demonstrated by subsequent discoveries that were prompted by the War between the States in North America. It was during the 15 years following the declaration of that war in 1861 (1861 to 1876) that there was more fruitful advancement in the art and science of ice making, meat, fish and milk conservation, than had occurred in the 113 years since William Cullen had triggered the investigation on how to produce man-made cold, and William Black unfolded the mysteries of the latent heat of evaporation and of fusion in his related studies. These advancements were made largely by individual United States rebels to preserve the integrity of the semi-tropical coastal states bordering the Gulf of Mexico.

From 1861 to 1865 ice from the northern states, either by ocean route or by Mississippi River delivery, was not available to the Confederacy. They harvested and stored some from the mountain tops of the South but in winter little of this ever arrived at the tropical Gulf ports.

When war was declared in 1861, between the Union and the Confederacy, Boston ice was no longer available to the Gulf ports; the hospital equipped with a Dr. Gorrie compressor was the only Gulf Coast institution that could adequately care for fever patients.

Within two years after the declaration of war, small Carré absorption refrigeration machines were brought through the blockade from France, in 1883, by Bujac and Girade of New Orleans. One was used at Augusta, Ga. Convalescent Hospital and a second came through the blockade at Matamoros, Mexico and was delivered to Brownsville, Tex. for installation on the King Ranch.

Until 1880, the story of the advance in mechanical refrigeration (world-wide) was primarily the progress being made in ice making and in meat and fish processing and preservation with a few notable examples of beer making, oil dewaxing and wine cooling in United States, Europe and Australia. Air cooling for comfort was obtained by ice and by chilling systems from either "lake" or "ice plant" ice.

The period from 1844-1845 to 1884-1885 reflects the essential need of refrigeration to advance the economy of North America's semi-tropical areas. The calendar of successful American inventors and inventions covering these two decades in refrigeration progress is presented herewith.

THE CALENDAR OF SIGNIFICANT REFRIGERATION INVENTIONS AND DISCOVERIES – 1865-1885

And the Americans Who Made These Contributions Depicts Much of the World Progress in Refrigeration Until 1885

In 1865, after the war, Daniel Livingston Holden bought one of the Carré units from Bujac and Girade of New Orleans and set it up in San Antonio. He operated for one season making commercial ice but ran into difficulties making the fuel-fired generator work successfully. Further, the San Antonio water produced an off-color ice. Holden's first improvement was to place steam coils in the generator to heat the aqua ammonia. His second improvement was to produce the ice from distilled water. This placed the Carré machines on a commercial basis. Holden-type Carré machines were installed and operated at Shreveport in 1866 and at San Antonio in 1865-1866. In 1869 a Holden-type Carré plant of 60-ton capacity, the Louisiana Ice Works, was built in New Orleans.

Holden in 1869 took out U.S. Patent No. 95,347 on a special freezing machine called the "Regealed" which was manufactured in Philadelphia for some years. He also acquired the patent rights of Peter Van der Weyde's compressor U.S. Patent No. 87,084 of 1867 using naptha as a refrigerant and installed many of these units in Texas and Louisiana before 1870.

In 1867 and 1868, Thaddeus S.C. Lowe built a carbon dioxide compressor to inflate his lighter-than-air observation balloons, then converted two to making "dry ice" for Dallas, Tex. in 1867 and for Jackson, Miss. in 1869. Lowe also installed one of these dry ice machines on the William Taber and transported frozen beef from New York to several Gulf ports in 1869.

In 1867, Henry Peyton Howard (1829-1913) of San Antonio transported a shipload of frozen beef from Indianola, Tex. to New Orleans and served it in hospitals, hotels and restaurants.

In 1869, John Beath (1831-1917) and Samuel Martin of San Francisco, Calif. built compression machines in Los Angeles, San Francisco and Portland, Ore. and secured U.S. Patent No. 127,180 in 1872. Beath independently secured absorption system patents in 1873 and established plants in Chattanooga, Atlanta, New Orleans and Galveston. After Beath and Martin parted company in 1872, Beath specialized in absorption systems.

In 1871, Andrew Muhl (1831-1891) of the United States built a machine at San Antonio and took out U.S. Patent No. 121,188. He operated this machine in 1867 and, in 1871, built an ice plant of his own design. He took out a second U.S. Patent No. 146,267 in 1874, on a refrigeration system and made a contract with the Columbus Iron Works, Columbus, Ga. for its promotion (canceled after two years).

In 1872, David Boyle (1837-1891) of Scotland and Mobile, Ala., invented and operated an ammonia compressor, U.S. Patent No. 128,448. He operated his first machine at Jefferson, Tex. 1873 and made ice for one season. This was the first commercial compression plant in the world using ammonia to make ice. With the aid of R.T. Crane, he built three ammonia compressors, one for the King Ranch in Texas, one for Austin, Tex. and one for the Philadelphia Centennial Exposition in 1876.

In 1872, David Smith (1834-1903) of Scotland and the United States was the original inventor of the plate ice system. He was on military assignment in San Francisco at this time. By enclosing the ammonia pipes in long metal containers, he prevented contamination with the freezing water between the metal surfaces. Plate ice was thus formed and released for harvesting by sending hot gas through the freezing coils.

In 1873, Elbridge H. Holden (1841-1922) of Kentucky and Ohio, established the first mechanically refrigerated abattoir at Fulton, Tex. in partnership with his older brother, Daniel. It had a capacity of 100 head of beef a day and was successfully operated until 1881.

In 1874, Francis V. DeCoppet of the United States, three years after his application, received U.S. Patent No. 156,056 on an ammonia compressor. He had participated in the installation of Carre absorption units in 1868 and 1869 with Sylvester Bennett at Gretna, La.; the De La Vergne Refrigerating Machine Co of New York and the Fred W. Wolf Co of Chicago used DeCoppet compressor patent rights. DeCoppet, in 1874, received an additional U.S. patent on an improved absorber used by Blymyer & Co of Cincinnati.

In 1876, Thomas L. Rankin (1839-1915) of the United States participated in the building of the Louisiana Ice Works, 1868-1869, in New Orleans and then turned to improving the absorption system for breweries, ice houses and packing plants. He received U.S. Patent No. 175,498 in 1876 to install that system in the Jacob Ruppert brewery, New York City. Rankin was one of the first inventors of refrigerated railway meat cars, manufacturing them at Denison and Dallas, Tex. in 1872. Railroad promotion pressure is reputed to have opposed shipping chilled meats. Their investment in cattle cars would be imperiled by transporting meat under refrigeration.

In 1876, Harrison D. Stratton (1847?-1928?) of Philadelphia Franklin Institute reviewed the performance of the Carré absorption machine at Augusta as used for hospital ice during the war. He was employed to help direct building the 60-ton Louisiana Ice Works Plant, New Orleans, 1868 to 1870. In 1876 he received a U.S. patent on an absorption system that became the basis for several score plants built by the Columbus Iron Works, Georgia.

In 1877, Liecester L. Allen (1832-1912?) of the United States received U.S. Patent Nos. 193,631 and 237,359 and 237,360 on the Allen dense-air refrigeration machine for the United States Navy and kindred uses.

In 1877, Gustafus F. Swift (1839-1903) of the United States put into operation a refrigerator car to ship fresh meats which 15 years later had expanded to 97,000 refrigerated transport units. He overcame railroad opposition by owning his own refrigerator cars.

In 1878, Charles J. Ball (1846-1901) of St. Louis built an absorption ice plant in Sherman, Tex., patterned after the Holden and Rankin designs but using a separate slide-valve engine to drive the aqua-ammonia pump, the cold-water circulation system and other auxiliaries. His 5-ton plant cost $12,000.

In 1880, Fred W. Wolf (1837-1912), refrigeration engineer and brewery architect of Germany and Chicago, built his first Wolf-Linde ammonia compressor and installed it in Chicago. The Fred W. Wolf Co. which he had established in 1867, is still in the refrigeration business as a Wolf-Linde manufacturing operation.

Also in 1880, Charles Zilker (1864-1946) of San Antonio and Austin, Tex., built absorption plants of his own design, beginning in 1880, across the Gulf states and north to Pittsburgh. His plants were usually manufactured by local machine shops without patent protection. He designed and built absorption plants from Austin eastward to Atlanta, then northward to Pittsburgh. In 1928 he sold the entire system to the Insull Interests, Chicago, at $1,000,000 "cash on the barrel head."

In 1881, John C. De La Vergne (1840-1896) of New York built his first refrigeration machine with the help of William H. Mixer and established the De La Vergne Machine Co in New York City. He was very successful as a designer of ammonia compressors for ice plants, cold-storage houses and breweries.

In 1882, George Frick (1826-1892) established an engine works at Waynesboro, Pa. He signed and delivered, for Norris Ferguson of Baltimore, a vertical ammonia compressor to be driven by a Frick horizontal engine. Hundreds of Frick compressors were subsequently installed around the world.

Later in 1882, Ernst Vilter (1834-1890) of Germany and Milwaukee developed his first refrigerating machine, a horizontal double-acting steam-driven unit, and installed it at Milwaukee. The Vilter Co is one of the oldest continuous manufacturers of refrigeration machines in North America.

In 1884, Thomas Shipley (1861-1930) joined York & Co and developed many patents for them.

While these 20 years revealed new names in the listing of ice making equipment and systems that appeared on the European and American markets, many of these systems were unable to meet the rising competition of more adequately planned, advertised and financed refrigeration systems and designs.

Noteworthy of those manufacturers that had survived the free enterprise competition were York Ice Machinery Corp of York, Pa.; Frick Co of Waynesboro, Pa.; Carbondale Machine Co of Carbondale, Pa.; John C. De La Vergne Machine Co of New York City; Henry Vogt Machine Co of Louisville, Ky.; Vilter Manufacturing Co of Milwaukee, Wis.; Fred V. Wolf Co of Chicago; Columbus Iron Works of Columbus, Ga.; Charles Zilker of Austin, Tex.; and Baker Ice Machine Co of Omaha, Neb.

THE TURN OF THE 19TH CENTURY SALUTES THE 20TH – 1885-1940

(With the Expanding Facilities for Manufacture of Refrigeration Machinery for Ice Making, Air Cooling, Cold Storage and Construction of Household Refrigeration)

By 1885, the United States had established her world leadership in refrigeration, especially in the field of ice making, beer, air, meat, fish and milk cooling and the storage of butter, eggs and cheese. Australia and New Zealand were, however, running a close second, especially in the mechanical refrigeration preservation and shipping of meats, fish, dairy products and the production of beer. They found the desirability of cold storage houses to preserve foods in hot climates and solved the problem of moving millions of pounds of slaughtered beef and mutton across the equatorial waters by steamships.

By this time there were several compression type refrigeration machines on the market designed to be driven by horizontal engines of the newer George Corliss type invented in 1849. The condensate from the steam engines also furnished the distilled water for making the clear ice competitive with northern lake ice. This condensate did, however, have to be processed in a re-boiler to skim off the cylinder oil that had been fed to the steam cylinders for effective lubrication.

Within the southern United States, the original absorption type machines still prevailed. One Cincinnati manufacturer in 1890, boasted in his advertising that over 400 U.S. ice and other refrigeration plants were equipped with their absorption units as of that date.

The Corliss engine compression type refrigeration plants rapidly replaced the absorption designs, however. While the absorption plant was very efficient, especially at low temperature applications, most operators were poorly informed in the chemistry of aqua-ammonia absorption ice making and they complained that such machines were too temperamental to be pushed for production to meet hot summer ice demands.

The discovery that either vibration of the ice cans after being filled with city tap water or the equivalent forced air circulation with resultant bubbling agitation within the freezing can could produce as clear ice as was obtained by distilling the water, soon made distilled water an unnecessary expense in ice making.

In New York City in 1900, Tammany Hall politicians became involved in ice making. Tammany politicians entered into an undercover participation in the production, sale and distribution of ice in Greater New York through the American Ice Co, familiarly called the "Ice Trust." Commercial river, lake and machine ice was under the control of the American Ice Co and to punctuate this developing scandal the price of ice per 100 lbs was raised in 12 months from 30 to 60 cents.

New York City's Mayor, several judges of New York City and a democratic candidate for Governor for the State of New York were all heavy stockholders in this "Trust" that had illegally cornered the ice market.

In many other northern regions, volumes were written by the two sides as between the merits of lake and machine-made ice. Much that was written was technically unsound as reported from both sides.

This economic battle had started in 1848 when Alexander Twining built his ice plant in the midst of lake ice houses at Cleveland. By 1900, machine ice could be made as cheaply as lake ice could be stored at Cleveland. For the next 40 years, both forms of ice had a very satisfactory market. With the invention of the electric and gas household refrigerators, however, the market changed for household ice and virtually ended by 1950.

At the height of the world depression, June 16, 1933, Congress created the National Recovery Administration and placed Brig. General Hugh S. Johnson in charge. Johnson's administration was destructive of new small industry and virtually created a government controlled trust to protect already established enterprises. This new form of an "ice trust" enjoyed two and one-half years of high handed dictatorial management all of which was adjudged illegal by the courts in January 1936, when free enterprise was again returned to the industries in the United States both large and small.

It was in this political atmosphere that the American Society of Refrigerating Engineers (ASRE) came into existence in 1904. The history of the progress of refrigeration in North America, after the organization of ASRE, is best told within the calendar of events of 30 years related thereto, published in the December issue of Refrigerating Engineering in 1934.

ASRE was organized in 1904 at the headquarters of the American Society of Mechanical Engineers (ASME) then quartered at 12 W. 31 St. New York City. John E. Starr was chairman and William H. Ross was secretary. The first meeting of ASRE was held on December 5 that same year and John Starr was elected president. The new Society had 70 charter members and took pride in being the only engineering group in the world confining its activities to refrigeration.

The calendar in the 1934 December issue of Refrigerating Engineering continues: In 1905, ASME established 288 000 Btu in 24 hrs as the commercial ton of refrigeration within the United States. The same year the New York Stock Exchange was cooled by refrigeration.

In 1906, clear ice was first made without distilling water, and heated conflicts began to arise in American cities as between natural ice agencies and those producing ice by mechanical processes.

By 1908, the first International Congress on Refrigeration was organized in Paris and the United States sent a delegation of 26 men, mostly members of the newly formed ASRE, to participate.

By 1909, the conflict of interest between producers of natural ice and the owners of ice producing plants aroused the legislatures of several northern states. Some states proposed to make it illegal to make ice within their boundaries by machine methods.

In 1910, the National Assn of Practical Engineers was organized on December 1 at Shreveport, La. For the next 50 years the chapters of this organization continued to spread over the entire United States: their membership being made up primarily of the manufacturers, managers and maintenance men. This was a period of rapid advances in refrigeration progress. For the 10-year period from 1911 to 1921, the editor of Refrigerating Engineering reported the following historical items of significant interest to refrigeration engineers:

1911—General Electric began the manufacture of the Audiffren household refrigerating machine.

1912—The Psychrometric Chart of Air Properties was presented by Dr. Willis H. Carrier and published by ASME and ASRE.

1913—Homogenizing of ice cream became a commercial practice in the United States.

1914—The Southern Ice Exchange erected a monument at Apalachicola, Fla. to John Gorrie, M.D. (1803-1855).

1915—Refrigerating engineers, et al. met at San Francisco at the International Engineering Congress at the Pana-Pacific Exposition.

1916—ASRE approved condenser data published, also data on food temperatures prevailing in transit, and the Bureau of Standards published new heat transfer values.

1917—The largest cold storage plant in the world was built in New York with a capacity of 8,700,000 ft.

1918—Ice plants were closed in many cities of the United States to save coal on account of the war-time fuel shortages.

The National Assn of Ice Industries were formed from numerous divisional groups to coordinate their activities.

As of 1918 ASRE had 300 members.

1919—Electric power began to dominate refrigerating plant drives and high-speed, short-stoke compressors invaded the field.

Ice had found so many new uses that a shortage of ice-making capacity was cited in main cities both north and south.

The total installed capacity of refrigeration in the New York area alone was reported at 55,723 tons but this did not meet the demand.

Armour built a 50-million lb sharp freezer in anticipation of the new age of frozen meats and other frozen foods.

The first draft of a safety code for refrigeration plants was published.

1920—The standard ton of refrigeration definition for United States was adopted by the ASRE and ASME.

Methyl chloride entered the picture of refrigeration for the first time.

Direct expansion in ammonia coils became more popular in cold and freezer storage rooms.

1921—The open winter of 1920-1921 cut the natural ice harvest and this emphasized the shortage in national machine ice making capacity in the United States.

The government regulation of cold storage reached the stage of a bill in Congress (Congressional Record, Feb. 9).

In 1922, there was a post-war depression. Some war-financed refrigeration machine manufacturers' names were deleted from the listing of refrigeration equipment manufacturers.

After 1922, the national economic recovery was rapid, however, and maintained through 1929.

In 1923, the air-cooled small refrigeration machine was developed, and the research and engineering work continued on small refrigeration machines. A total of several thousand refrigerators of 19 different types was made up and field tested in the homes of GE officials and employees in widely scattered cities, at the expense of millions of dollars. Further improvements and refinements were developed in 1926, and then began the manufacture of the famous General Electric Monitor Top unit on a large scale production for household and store use.

This period was significant in refrigeration circles because it introduced a new type of small relatively short-lived, high-speed compressors and refrigeration systems that were subsequently to become highly competitive within the industry with the manufacturers of the slower-speed, longer-life machines that had commanded the market during the early period of the 20th century. The association of the manufacturers of the larger equipment was established under the familiar title of RMA which stood for Refrigerating Machinery Assn. Coming into existence, related to the smaller high speed compressors and the electrical industry, was the association to be familiarly known as NEMA or National Electrical Manufacturers Assn. Within a few years the corporations under these two banners were to become highly competitive, especially in the capacities of refrigeration plants from 3- to 30-tons capacity.

The NEMA manufacturers had the advantages of much less weight per competitive units, and thus could manufacture for less money. RMA manufacturers had the definite advantage of much longer-life equipment. These two types of equipment competing for business during the world's greatest depression caused much competitive friction within ASRE. Finding a common denominator to establish codes of acceptable standards became one of the most important functions of ASRE until its amalgamation some years later with the American Society of Heating and Ventilating Engineers (ASH&VE) into the present-day ASHRAE. (In 1954, the American Society of Heating and Ventilating Engineers [ASH&VE] changed its name to ASHAE.)

By 1930 however, the bottom fell out of the stock market and a world-wide depression set in: the refrigeration industry did not fully recover until World War II. This period, however, did go forward in refrigeration research and ushered in a full scale advance in freezer locker storage: new refrigerants of the "Freon" group, higher speed compressors, not only for household use but also for 3- to 500-ton ice making capacity plants. Many new plants installed 50 hp synchronous motors, when needed capacity permitted, to help make the power factor loading of the city power distribution system concerned more stable.

In the food field, inventions and discoveries under the caption of quick freezing not only advanced the science and economics of perishable food preservation, but the cold and freezer storage practice, world-wide, had to change primarily from a business venture where not more than 20% of all the warehouse investment had been economically devoted to freezer storage to an expanding practice where the national investment and operations were devoted, in most centers, to as much as 80% freezer storage, and not more than 20% to cold storage. Not only changes of equipment designs throughout all warehousing establishments were made necessary but the warehouse buildings and their insulation and basic designs had to go through revolutionary changes.

With the advent of quick freezing, there developed a cold storage practice of building storage houses devoted to a single product that required an atmospheric control to meet that product need, such as warehouses for apples, pears and grapes, or for citrus fruit or furs and fabrics.

It was during this period that the locker freezer storage plant installations expanded from a few in California and Nebraska in 1910 to a peak in 1951 of 11,600 with some 5,000,000 patrons. By 1951 the increase of locker plants per annum was arrested by the trend to use the food freezer in the individual home. It is estimated that in the United States alone there were ultimately 1,850,000 home freezers.

FROM WORLD WAR II TO 1968

Including the Consolidation of ASRE and ASHAE in 1959

By 1940 and the beginning of World War II, the art of air cooling was introduced in an ever increasing number of applications. Air cooling of department stores, restaurants, hotels and hospitals became an accepted practice and extended research was underway in the preferred methods of cooling automobiles, airplanes and homes. The war arrested much of this type of research except as it was related to the war efforts and economy. As is characteristic in most post-war periods of the United States, there was a brief recession followed by an upturn in almost every phase of the refrigeration industry. In air flight, air cooling combined with pressurizing of planes, became a must. All passenger ships, buses, and railroad passenger cars found space refrigeration most essential to customer transport. Not only must restaurants and hotels be completely refrigerated in both rooms and eating centers but 100% air cooling of all space of public entertainment and office buildings, even small stores, variety chain stores and most homes south of the 40th parallel demanded some form of air cooling. The frozen food industry including all processing of meats, fish, poultry and fruit had to operate under increasing public health regulations of refrigeration. The refrigerated warehouse for the cold and freezer storage of most all perishable edibles, except those fruits and vegetables of tropical origin, was accepted as essential to their economical preservation. Hundreds of new applications of refrigeration for conservation and preservation are now current as of 1969 for museums, libraries, printing plants, textile processing, dam building, metal treatment and nut and vegetable preservation.

What was begun in 1748 by the Scottish physicians, 220 years ago, has become one of the most essential parts of established American life and economy. The men who formed ASRE in 1904 planned well and expanded their obligations consistent with American economy; their uniting in 1959 with ASHAE brought together two organizations whose principal objective was heating, refrigerating and environmental air conditioning, not alone for the American people but also for the millions of persons of other lands on this planet Earth who are now recipients of the refrigeration research, production and education that has emanated from the membership of ASHRAE, interested in the production of cold for the benefit and advancement of mankind.

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HOW MUCH PROGRESS?

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Presidential Member ASHRAE

MOST of us tend to judge the past in terms of the present or conversely, to picture the past as more primitive than it actually was. This article will present the environment that existed in our industries and in the country generally during the decade of the 1890's when our Society was founded. I have no intention of predicting the future but there are some comments on the present state-of-the-art.

The decade of the 1890's was a period of turmoil and extremes, it had the worst money panic the country ever experienced and yet it was called the "Gay Nineties." The buying power of the dollar rose to an all-time high of $1.75: our present dollar is worth 35 cents on the same base. Some 92% of the families had incomes of less than $380 per year, equivalent to less than $2000 today.

Industrialization was moving ahead with robust strides and great fortunes were being amassed. Labor was beginning to organize. There were 1300 strikes during the single year of 1892. A 12-week strike of 75,000 mine workers won them an 8-hr day instead of the 10- or even 12-hr day which was normal at the time.

Coxey's Army which was protesting the plight of workers and farmers marched into Washington, where Coxey was promptly arrested—for walking on the grass. The entire faculty of Kansas Agricultural College was fired for their political views.

Except for the two terms of Grover Cleveland, there had been a continuous succession of Republican presidents since the time of Lincoln. Big business was in control of every branch of government including the Supreme Court. It was a time of "let the public be damned."

Our conglomerates of today are pikers compared to the big trusts of the '90's. Presidents Cleveland and McKinley made no effort to enforce the Sherman Anti-Trust Law. In 1895 the Supreme Court ruled that the American Sugar & Refining Co was not a monopoly even though it controlled more than 95% of the nation's refined sugar production.

All through the West, the indians were being pushed aside by the white man's expansion. In 1893 when the Cherokee Strip was opened, 100,000 people awaited the signal to rush in and claim a piece of the public domain.

The robust nature of the times was exemplified by the Chicago World's Fair held in 1893. The central attraction was a giant wheel designed by George Washington Gale Ferris. This Ferris wheel was 250 ft high with 36 cars holding passengers each for a total of 1440 passengers. The exposition buildings were lighted by 8000 arc lamps and 130,000 incandescent lamps. Seventeen thousand horsepower steam engines drove the electric generators. This was three times the electric lighting power used by the entire city of Chicago.

An excellent account of the 1890's has been given to me by John Redeker, 91 year-old father of ASHRAE member Phil Redeker: "Travel was mainly by horse and buggy most of the year and by sleigh in winter. I was required to wash and wipe our double-seated carriage after

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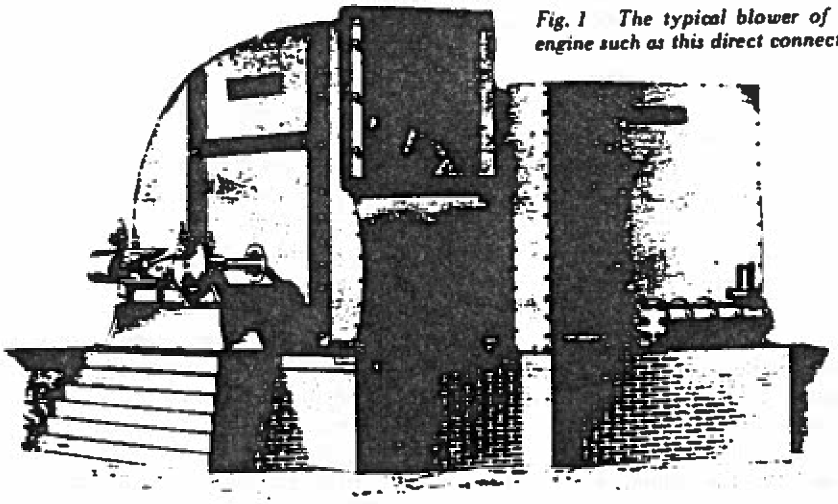

Fig. 1 The typical blower of the 1890's was driven by a steam engine such as this direct connected Sturtevant model

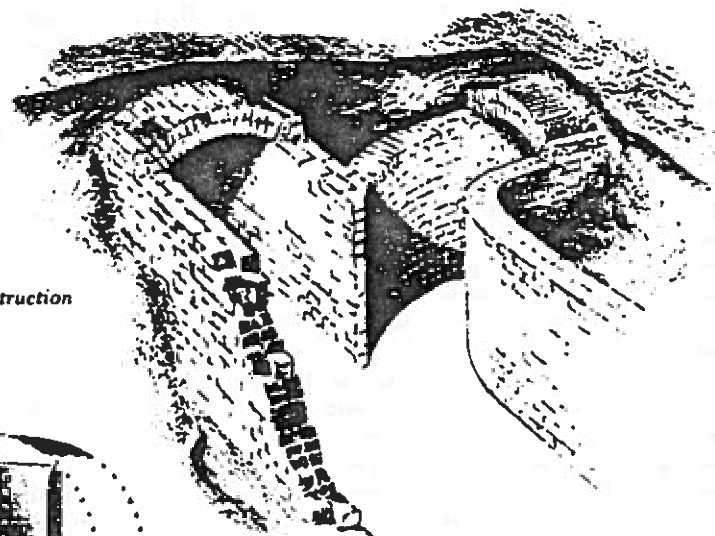

Fig. 2 Large ducts were usually of masonry construction

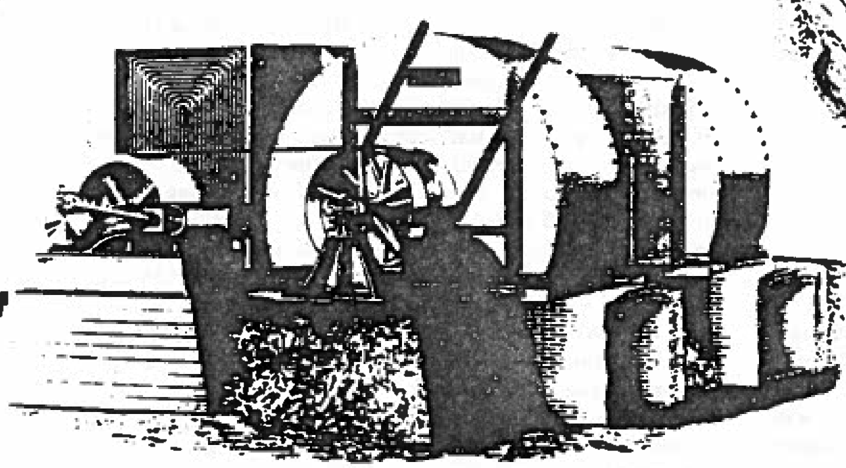

Fig. 3 Large blowers were frequently positioned directly on the masonry ductwork as shown by this belt driven arrangement. The square enclosure is the heater. It was a double-duct system

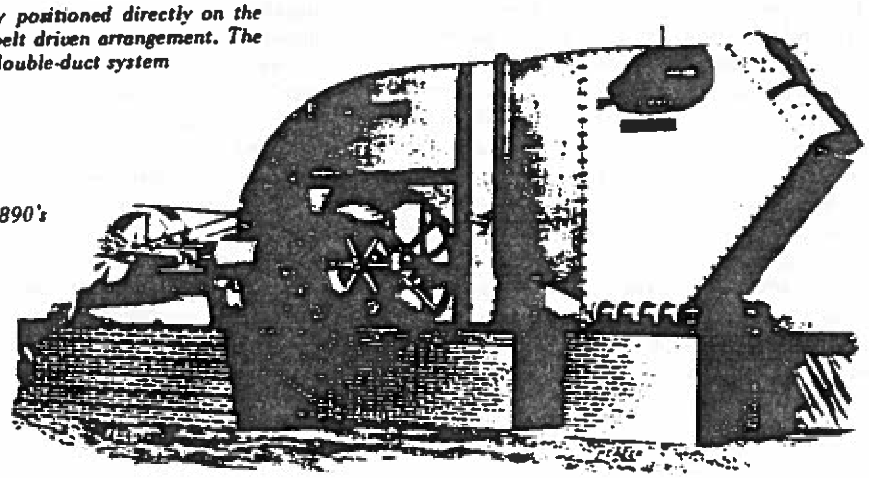

Fig. 4 A double-duct system of the 1890's

every trip and to cover it with a blanket to keep the dust off. Nowadays most people do not even wash a $6000 automobile once a week. Horse-drawn streetcars were being replaced by electric trolleys. Town sports used to go down to Fountain Square to watch the ladies lift their skirts and display their ankles when they got on streetcars." Things are different today—we have no streetcars.

If you wanted a horseless carriage, you would have found a better choice among European makes but several American models were on the market, such as the early Oldsmobile and the predecessor of Henry Ford's Model T.

Prior to the 1890's there had been numerous instances of cooling air for comfort by the use of ice and even with mechanical refrigeration, but air conditioning as we know it today was many years away. Heating and ventilating of large buildings was well advanced although electric power was not generally available. The typical blower (Fig. 1) was driven by a steam engine with exhaust from the engine used for steam heating. Large ducts (Fig. 2) were generally constructed of brick. Blowers were frequently set directly on the ducts (Fig. 3) with brickwork forming part or all of the scroll shape.

A box-like housing behind the fans in Figs. 1 and 3 contains the steam heater, constructed of pipe and fittings. Only one of the two fans in Fig. 3 handled heated air – a *double-duct* system! Fig. 4 shows another double-duct system that was available during the 1890's and is identical in arrangement to present-day equipment. Electro-pneumatic instruments were being produced by Johnson Service Co for automatic temperature control, including actuators for double-duct dampers. The need to distribute air without unpleasant drafts was well recognized. Fig. 5 is a good example of an early grille design. Discharge grilles were even combined with theater seats as shown in Fig. 6.

The pot-bellied stove was standard equipment for heating stores and many other spaces. A more handsome version was used in homes and was often equipped with an extension for heating the upstairs. Large homes, hotels and offices were usually heated with steam radiators. They took all shapes and sizes and included the dining room radiator (Fig. 7) with a food warming cabinet.

Gas manufactured from coal was available in most cities and was used extensively for illumination. It burned with a bright yellow flame that gave off more heat than light, and was frequently used for heating small spaces.

Furnaces fired with coal or coke were coming into use. A unique device for automatic control of furnace dampers was produced by the forerunner of Honeywell Co. Since electricity was not generally available, the device was motivated by a spring that was wound up when the furnace was fired. A thermostat controlled battery current to a coil that released the spring to open or close the damper.

Turning to refrigeration, I will again quote Mr. Redeker: "Such preservation of fresh food as there was then was in iceboxes with ice cut from lakes and rivers and stored in hay in ice houses. Some fruits were stored in cool cellars or root cellars and there was putting up and pickling of preserves and other foods in glass jars." Iceboxes such as mentioned by Mr. Redeker were priced in Sears & Roebuck's 1897 catalogue at less than $15 for a two-door model suitable for a medium-sized family.

In the country and small towns, ice was chopped from lakes and stored in ice houses that were often partially underground for protection from heat. In larger cities, ice was harvested more efficiently and the ice house was usually located close to the source of supply (Fig. 8). Natural ice, however, was on the way out. The winter of 1890 was unusually warm and resulted in an ice famine. But the most serious trouble came from pollution of rivers and lakes by untreated sewerage. One ice company brought suit against the city of Passaic, N.J., whose sewerage was ruining its business. The Chicago Health Dept forbade the sale of Lake Michigan ice for domestic use and health boards in many other cities were taking similar action.

Thanks to the demand by breweries for mechanical refrigeration, the industry was ready to supply machines for making artificial ice. In a single issue of the monthly magazine Ice & Refrigeration, during 1894, there were advertisements by 17 manufacturers of ammonia compressors. They all included a steam engine as part of the compressor assembly (Fig. 9). A 200-ton York machine operated at 50 rpm and weighed 155,000 lbs. Today, a steam-driven centrifugal compressor of that weight would produce 10,000 tons. A heated controversy was being waged in the periodicals between Frick, De La Vergne and Philadelphia Iron Works over who made the world's largest refrigeration machine. De La Vergne and the Philadelphia Iron Works had 500-ton machines. Frick's machine was rated at only 350 tons but was physically larger than the others. It required a complete train of 15 flat cars to ship it from Waynesboro, Pa., to Kansas City. This controversy over who made the largest compressor was complicated by the lack of a uniform method of rating. It would be several years before the formation of the American Society of Refrigerating Engineers (ASRE) and the establishment of the standard ton of refrigeration.

Among the smallest machines advertised was a two-ton unit with horizontal steam cylinder by Frick weighing 4300 lbs and a similar capacity machine with vertical steam cylinder by York (Fig. 10). The York unit operated at 140 rpm and weighed 6000 lbs.

In keeping with the spirit of the times, the ice industry was the center of intensive monopoly efforts. Refrigeration of cold storage rooms was with ammonia circulated through bare pipes strung on walls or ceilings. The pipes were spaced on wide centers to allow for heavy frost accumulation. Some jobs could run six months or more between defrostings. Then the thick layer of frost was knocked off with clubs after loosening it with hot ammonia gas through the pipes.

ASHRAE, along with the air conditioning and refrigeration industries, have every right to be proud of the progress made during the past 75 years. Air conditioning and mechanical refrigeration have become an essential part of our daily lives. The dollar volume of industry sales and the growth of membership in our Society depict a healthy situation. However, it would be foolhardy to bask in pleasant statistics to the extent that our shortcomings are ignored. What better time to take stock of ourselves than at this 75th Anniversary Meeting.

In the field of air conditioning, we do a particularly poor job on the small and medium size installations such as motel rooms, hotel rooms, small restaurants and residences. We cool them during the heat of summer and heat them in winter. We call this year-round air conditioning but, too often, we fail to provide comfort during the in-between seasons. It is a common experience at those times to turn on the air conditioner and get a blast of hot air when cooling is needed, or, even worse, on a mild humid day to find the air conditioning useless because it over-cools

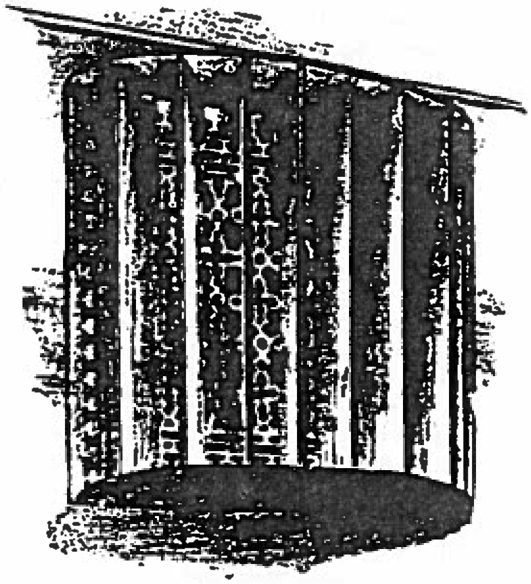

Fig. 5 Much attention was given to discharge of ventilation and heating without unpleasant drafts

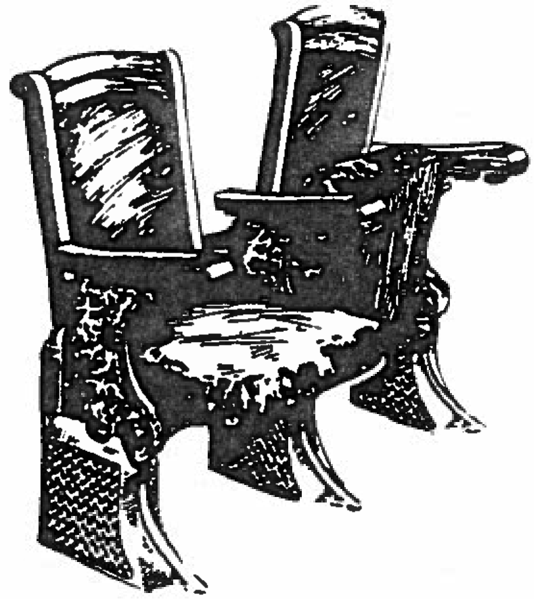

Fig. 6 A unique theater seat and discharge grille combination

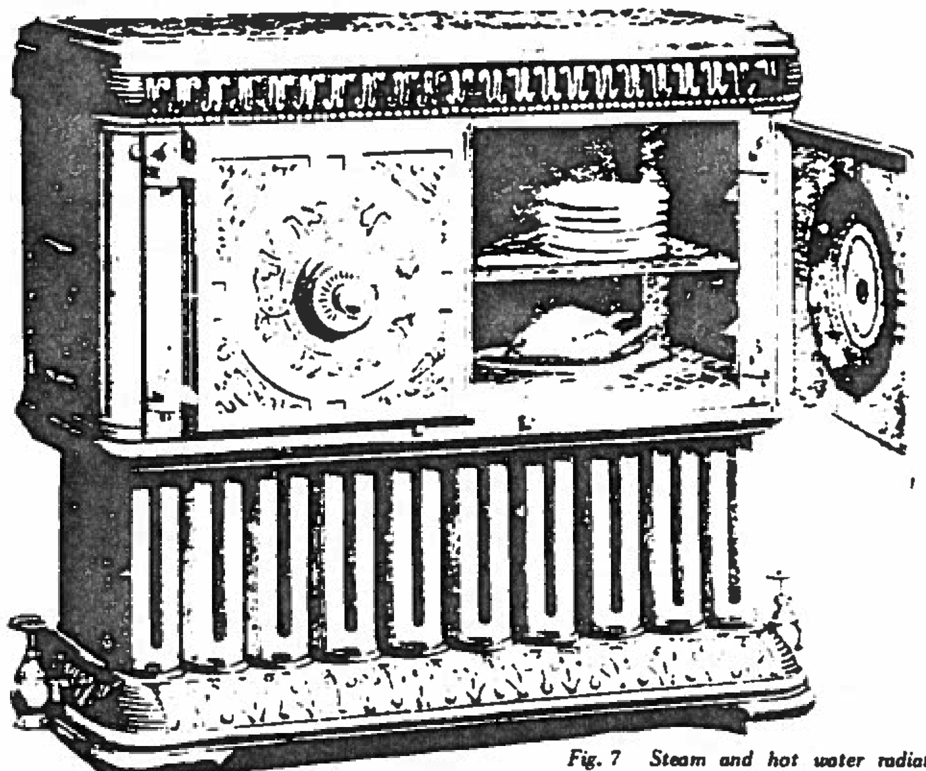

Fig. 7 Steam and hot water radiators came in many unusual shapes including this dining room model with food warming cabinet

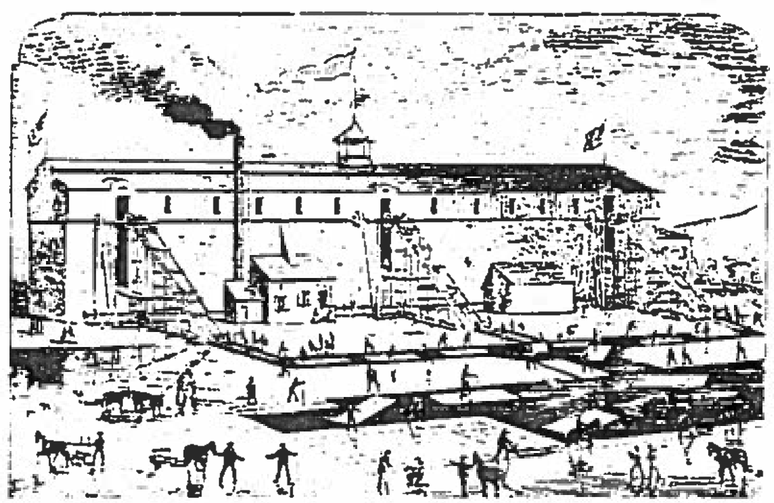

Fig. 8 Ice harvesting during the 1890's. However, natural ice was on the way out due to undependable supply and pollution of rivers and lakes

without reducing the humidity.

Here is one example of the problem. A notice to the occupant of a modern, multi-story motel tells of two swimming pools, sauna bath, color TV, etc. Now listen to what is said about the air conditioning:

> "We've attempted to provide the finest in central air-conditioning and heating equipment. Because of the fact that this is a centrally operated unit, we maintain a staff of engineers on duty 24 hours a day. During the spring and fall seasons, when the temperatures vary so much between daytime and nighttime hours, it is sometimes difficult to 'change over' the system without normal delay. If you have trouble with the equipment or controls, contact the front desk."

The air-conditioning unit was manufactured by a well-known company but was installed on an inside wall with no provision for outside air. The unit was noisy and it smelled from tobacco smoke. It had a fan control switch but the control knob was missing. A call to the front desk brought the information that knobs had been removed from all the units. After some persuasion, a knob was brought by the engineer and the unit turned off. Then, thanks to a cool evening and an open window, the room became comfortable; but note, not due to the air conditioning. This was not an unusual experience. During a recent trip I stayed in eight hotels and motels that were new and modern. Only one of them provided air-conditioning for the mild, in-between seasons.

Excessive noise and drafts are other criticisms of our air conditioning. When no provision is made for outside air, we are surely moving backward. During the first meeting of the Society, there were lengthy discussions on ventilation, including the need for ventilation of tenement houses. It may appear out of place to compare a plush motel to a tenament house but, without ventilation, they are not too far apart.

Our engineers are capable of designing good year-round air conditioning. Why then are we failing to apply principles that have been well-known for a long time? Most engineers blame the architect for using too much of the available money for aesthetic purposes and then subordinating the mechanical equipment. The architect, however, is not always to blame and cost, while certainly an important factor, may not be the sole consideration.

To be sure, it costs more to maintain comfort during mild weather but such cost is a small part of the yearly operation. The owner of that motel with good air-conditioning stated that any increased cost was more than off-set by reduced maintenance and the advantage of satisfied guests.

Some years ago, following a talk on this subject in Houston, there was criticism of the increased cost of operation during mild weather. The criticism was quickly resolved, however, by the disclosure of serious trouble in a large new office building where humidity was so unbearable that occupants were refusing to stay in the building. The air-conditioning system had been engineered for minimum operating cost without regard to the basic purpose of air conditioning which is to provide comfort for the occupants of the building.

Here is a recent example. A large residence in St. Louis had an air-conditioning system that was excellent during a hot day but useless during a humid evening. This was particularly objectionable when a large group of people were being entertained. The problem was corrected by applying well-known engineering principles. Had they been designed into the original installation, the cost would have been negligible.

FIVE RECOMMENDATIONS

I could go on and on with instances where the buyer was willing to pay for good air conditioning and thought he was getting it, only to find that it was unsatisfactory or marginal at best. While this is often the result of improper engineering it also comes from faulty communication between the interested parties. My remarks will conclude with five recommendations for ASHRAE action:

Number One. ASHRAE has a definition of air conditioning which states: "Air Conditioning: The process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space."

This is a well-conceived definition but is so general in nature that it creates misunderstanding. Anything that cools air is called an air conditioner and if it also heats air it is called a *year-round* air conditioner even though it may be useless during a large part of the year. So my first recommendation is for ASHRAE to define *various classes* of air conditioners in terms of what each class is supposed to do for the *occupant* of the conditioned space. These definitions will improve communication between the general public and the industry and eliminate much of the misunderstanding that now exists.

Number Two. ASHRAE GUIDE AND DATA BOOK covers many types of air conditioning from hospitals to hogs. It even tells how air conditioning affects the milk production of cows and the activity of bulls. But under the subject of hostelries is the following design recommendations:

> "...Prime consideration should be given to those systems which require the least space and are also economical from a total owning and operating cost viewpoint."

Not a word about ventilation or year-round comfort and, how different from a reference book, *written by an architect*, on hotel planning which states "No cost should be spared in the initial installation or in the maintenance program." So my second recommendation is to include in ASHRAE GUIDE AND DATA BOOK a review of the various methods for regulating the capacity of air conditioners with an evaluation of their ability to maintain comfort during mild, humid weather. Then under the subject of hostelries, along with the other applications, give some attention to ventilation and comfort of the occupants during all seasons of the year.

Number Three. ASHRAE has a comfort chart that gives the limiting conditions for temperature and humidity where most people feel comfortable. This chart has been a real contribution of our Society but it is too complicated for general use. So my next recommendation is to supplement the chart with information on temperature, humidity, and air motion in a form that anyone can understand.

Number Four. We have a chapter on Sound Control in ASHRAE GUIDE AND DATA BOOK with an excellent table on maximum permissible sound levels for various applications. Sound is a controversial subject because it affects people differently, but a noisy unit that turns on and off during the night is uncomfortable to everybody. The table should be expanded to include intermittent sounds.

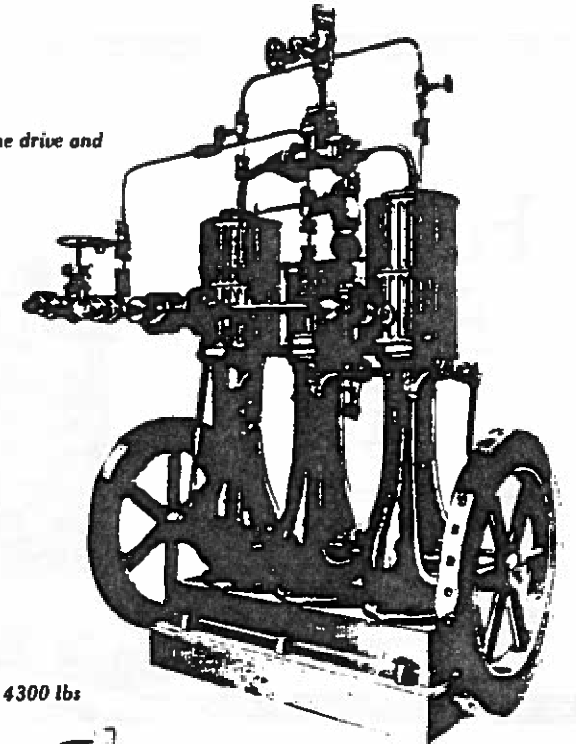

Fig. 9 Ammonia compressors included the steam engine drive and were very large compared to present practice

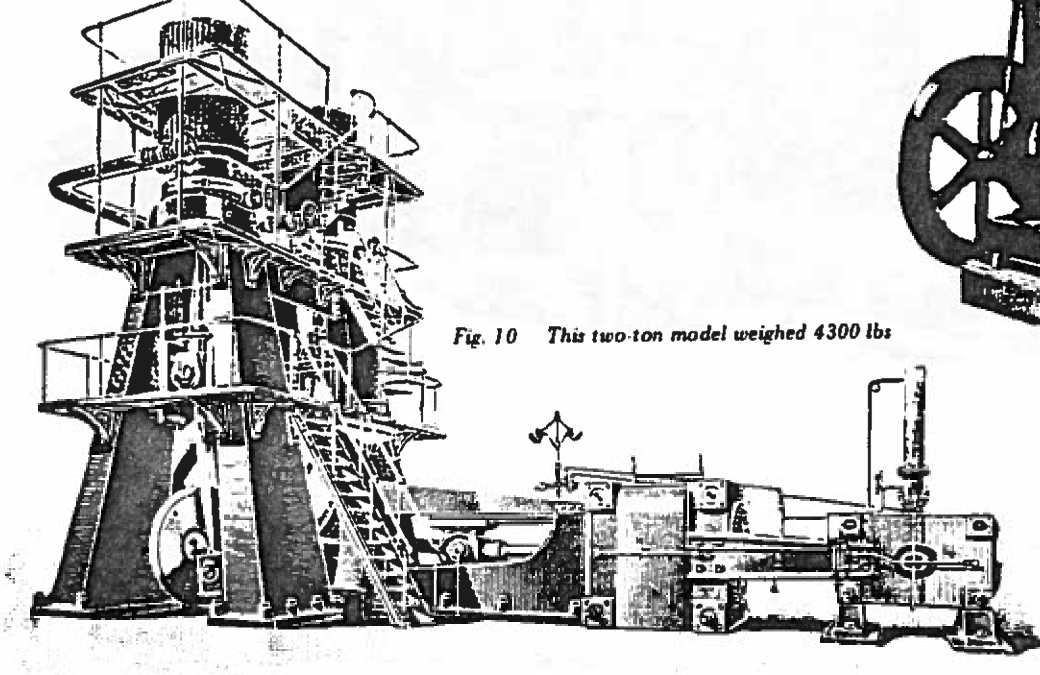

Fig. 10 This two-ton model weighed 4300 lbs

Number Five. My fifth and final recommendation is for a comfort air-conditioning standard to back up those definitions with minimum performance requirements. Year-round air conditioning would then be more than a misnomer for two-season air conditioning. This standard would in no way dictate the kind of air conditioners that are to be made nor would it limit design ingenuity. To the contrary, it would encourage good design by increasing the demand for better air conditioning from an informed public.

We have ample precedents for such a standard. One of the articles in the original constitution of ASH&VE states: "To establish and clearly define minimum standards of heating and ventilating for all classes of buildings."

For those who think that this subject may be outside the realm of a technical society, I refer to the second paragraph of our Bylaws which states:

> "Section 1.2 The object of the Society is to advance the arts and sciences of heating, refrigeration, air conditioning and ventilation, and the allied arts and sciences, for the benefit of the general public."

Our Society has made many valuable contributions to the air-conditioning and refrigeration industries. The time has now come to take another forward step and correct the misunderstanding of what good air conditioning really is. It cannot be done by individuals acting alone, but it can be done by our Society. Such action could stimulate a new growth phase in our industry. It will benefit our engineers, our manufacturers, our contractors and the general public. It is time to stop hiding our candle under a bushel basket: to let the public know that we know how to provide good comfort air conditioning.

ACKNOWLEDGEMENTS

Historical information and pictures relating to our industries during the 1890's, and other helpful material, have been generously provided by the following individuals and organizations: W. Aubrey, Frick Co; C. Snyder, Honeywell Inc; J. Chamberlain, C. Moore and A. Newton, York Div, Borg-Warner Corp; W.L. McGrath, Carrier Corp; F. Gall, Bell & Gossett Co; W.E. Tracy, Sturtevant Div, Westinghouse; H. Laube, Singer Corp; H. Jarvis, Recold Museum; F. Bridgers, Bridgers & Paxton; G. Muffly, ASHRAE Presidential Member; R. Tull, ASHRAE Presidential Member, Electric Space Conditioning Institute, Jersey Central Power & Light Co; H.C. Diehl, food technology consultant; P. Redeker, publishing director of Air Conditioning, Heating and Refrigeration News; A.J. Hess, consulting engineer; C.S. Perkins, A.C. Martin & Assocs; C.Logan, ASHRAE Presidential Member, "Recoin" Components Refrigerating & Air Conditioning; W.L. Holladay, ASHRAE Presidential Member, Holladay, Eggett & Helin; J.B. Graham, Buffalo Forge Co; M.M. Herrick, Johnson Service Co; and C.J. Harris, Ramada Inn, Oklahoma City.

History of Research in ASHRAE

BURGESS H. JENNINGS
Presidential Member ASHRAE

ASHRAE Research Laboratory in Cleveland used from 1946 to 1961

CHARLES F. Kettering once defined research as "an effort to do things better and not to be caught asleep at the switch." The desire to know how to do things better was uppermost in the minds of the founding fathers of our predecessor societies: the American Society of Heating and Ventilating Engineers (ASH&VE) and the American Society of Refrigerating Engineers (ASRE).

In the early days of these societies, the lack of standards and the uncertainty of the data required for rational design, manufacture and application created urgent needs. The practice of heating, ventilating, refrigeration and air conditioning was then more art than science. Although fundamental concepts were known, the confusion, which resulted from the conflicting claims of commercial interests, was widespread. Thus the need for accurate fundamental data, untrammeled by commercialism, was so strong in the minds of many ASH&VE members that, as early as 1916, serious thought was given to the necessity of having the Society set up its own research laboratory. In 1918, ASH&VE President J. Irvine Lyle appointed a committee to implement setting up such a laboratory, and on August 1, 1919 the ASH&VE Research Laboratory was officially established and began to function. This was made possible by the help given from the U.S. Bureau of Mines in Pittsburgh which contributed both office and working space for the laboratory.

On opening day, Dean John R. Allen assumed the directorship of the Laboratory. Mr. Lyle, then serving as chairman of the Committee on Research, in his annual summary, reported that to January 1, 1920, $3191.98 had been expended and the total budget provided by the Research Committee amounted to $20,000. In this report, Mr. Lyle, speaking for the Committee stated, "We recommend that a drive be instituted on March 1 and consummated on June 1 to raise the additional funds necessary to insure a $25,000 annual income, and that bills be sent to the subscribers on June 1 of each year. I am inclined to believe that we will have no trouble in raising this money in view of the splendid showing the Bureau has made up to date. We sincerely hope that every chapter and every member will feel sufficient interest in this work to enter upon this drive wholeheartedly to make it a success."

Before discussing research in detail, a few words relative to the Laboratory activity of ASH&VE should be given. The Laboratory's first director, Dean Allen, died in 1920 and was succeeded by Dean L.A. Scipio of Robert College. Dean F. Paul Anderson assumed the directorship in 1921 and served until 1925 when he returned to the University of Kentucky. The next incumbent was F.C. Houghten, who served longer than any other director, from 1925 to 1943.

Cyril Tasker, in October 1943, became the director and immediately faced the crisis of finding a new home for the Laboratory because war-time emergency made it necessary for the Bureau of Mines to employ all of its space for military research. He located a temporary site at 10700 Euclid Ave in Cleveland, Ohio and there the Laboratory operated until the final Laboratory site at 7218 Euclid Ave in Cleveland was bought by ASH&VE in July of 1946. Mr. Tasker died in 1953 and a new director, Elmer C. Kaiser, assumed office in 1954. He served as director until the spring of 1957 when he chose to return to industrial and educational research. In 1954 ASH&VE changed its name to the American Society of Heating and Air-Conditioning Engineers (ASHAE).

Burgess H. Jennings requested a leave of absence from Northwestern University and served as director until September 1960. His work was taken over by Clark M. Humphreys who, prior to this time, had served as associate director of the Laboratory.

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The Cleveland Laboratory was exceptionally well suited for research, containing some 18,000 sq ft of working area, with 13,000 used for active research projects and the remaining 5000 used for offices and meeting rooms. During its period of active productivity, a staff of about 25 engineers, technicians and aids served in the Laboratory, with large groups of physiological test subjects at times increasing the total to 50 or so individuals. The Laboratory over its 42-year life was extremely productive and its numerous papers represented the basis for a significant portion of the technical, scientific and design information which has enriched ASHRAE TRANSACTIONS, ASHRAE GUIDE AND DATA BOOK and ASHRAE JOURNAL.

The contributions of the Laboratory to the Society have been many and varied. Perhaps the most significant area of investigation involved the establishment of conditions for human comfort and the creation of the comfort chart. With the passage of time, modifications in original chart values were necessary and important aspects of re-evaluation were completed. Work on fundamental fluid flow of air, steam and water through ducts and pipes, air distribution from jets, design of steam and hot water systems, computation of heating loads, heat transmission, cooling loads, solar effects on walls, roofs and glass, the measurement of odors and their control, the performance of controls, problems in combustion, sound and vibration analysis, and coordination of weather data represent a few of the many areas which were carried out by investigations in the Laboratory.

However, paralleling in significance its own productivity was the cooperative research activity coordinated by the Laboratory. As new areas needing investigation were brought to the attention of the Committee on Research through its teams of Technical Advisory Committees, careful investigation was made as to where the fundamental research or testing should be carried out. With the fine facilities available in many university laboratories and with faculty members wishing to carry out investigations in areas of need to the Society, it was natural to develop cooperative research agreements between the Society and universities. The store of knowledge received by the Society through such cooperative research ventures was of inestimable value.

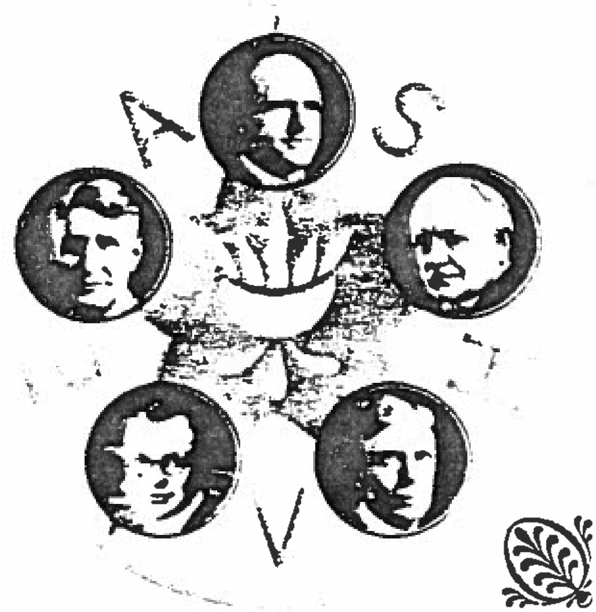
The Technical Advisory Committees of the Society appointed in the different areas of interest such as those on Air Distribution, Evaporative Cooling, Heating and Air-Conditioning Loads, Physiological Research and Human Comfort, Air Cleaning, Combustion, Control, Insulation, Sound and Vibration Control, Plant and Animal Husbandry, to mention a few, served a multiple purpose in that they planned and advised the Society on research approaches, correlated information from industry and other sources and published their analyses. Thus, research results accrued on several fronts, in the Society Laboratory, in university and industrial laboratories, and in field installations.

Prior to the merger of ASHAE and ASRE into ASHRAE in 1959, support of the Laboratory and its related research program was provided by ASHAE. The funds for this purpose came from three principal sources. A portion of the dues, received from each member, was allocated to the support of research; second, a contribution toward research was received from the income of the International Heating and Air-Conditioning Exposition; and the third portion of funding consisted of generous contributions made to the Research Program by industrial firms and individuals. The latter funds were given either for general research usage or restricted for support of a specific research area. In addition to this, the program frequently received support from associations and also from the federal government for specific projects of interest to the supporting agencies as well as to the Society. For the fiscal year prior to the merger of the societies, the research budget amounted to $234,000.

ASHAE and ASRE in 1958 voted to merge and the formal consolidation documents were signed in January of 1959. The emergence of ASHRAE resulted in some adjustments to the Research Program but these were not difficult and the transition was a relatively simple one. Prior to the merger, research papers were published in Heating, Piping and Air Conditioning and reprinted in ASHAE TRANSACTIONS. ASRE published its papers in its own publication entitled Refrigerating Engineering. After the merger, the Society publication took the name of ASHRAE JOURNAL and its first issue appeared January 1959. This official publication of the merged Society now includes research and meeting papers, reports and Society news, in a single publication. ASHRAE TRANSACTIONS continues to present Society records and reports, along with research and technical papers of permanent value presented before the Society at its meetings.

The need for fundamental data had been largely satisfied by intensive research programs and the large amount of knowledge produced in four decades minimized the pressing need for the Society to have a laboratory of its own. Also, with the federal and state governments pouring millions of dollars into research in their own laboratories and in the laboratories of many universities, the competitive position of a restricted-area laboratory to obtain financial support and to hold quality staff had become very difficult. Increasingly, the cost of necessary modern research tools such as multiple-purpose computers, spectrometry equipment, complex electronic devices, acoustical

The Founders Group for ASH&VE Research (from an early Society publication). Starting at the top and reading clockwise: John R. Allen, F. Paul Anderson, A.C. Willard, F.C. Houghten, and L.A. Scipio. All served as Directors of Research except A.C. Willard who was ASH&VE President in 1928



circuitry, and vibration analyzers, could hardly be justified unless the cost of such equipment could be shared through usage in numerous research areas as is the case in commercial and service laboratories.

ASHRAE, because of its character, could not change its Laboratory into a broad-based commercial enterprise and, in the face of the phenomenally rising costs which affected the future growth of the Laboratory, regretfully made the decision in 1961 to discontinue its operation—after 42 years. The fine equipment in the Laboratory was given to universities which had indicated a willingness to use the equipment to further the interests and needs of the air-conditioning and refrigeration industries. The physiological research chambers were given to Kansas State University. This equipment now functions effectively to produce continuing research results. The solar calorimeter, given to the University of Florida, continues to produce significant data on glass usage and fenestration. Instrumentation and other test devices were distributed to other universities.

The universities which have carried out cooperative research with ASHRAE and its predecessor societies include many of the distinguished engineering colleges in the United States and Canada. Although a complete listing of all of the schools might be tedious, some mention should be made of those universities which have greatly contributed toward furthering our research efforts. Prior to 1941, the most active schools were the University of Illinois, University of Minnesota, University of Wisconsin, Texas Agricultural and Mechanical College, University of Pennsylvania, University of California (Berkeley) and Harvard. Through 1941, the Laboratory and cooperating institutions produced 234 research papers. Activity at different schools varied from time to time and continuous Society work was hardly possible in any institution. Since 1941, those colleges participating in cooperative research include the University of California at Los Angeles, Cornell, Lehigh, Northwestern, Kansas State, University of Michigan, Michigan State, University of Iowa, Columbia, Pennsylvania State University, Case Institute of Technology, University of Florida, Ohio State University, University of Arizona and Purdue.

In ASRE, essentially all research was carried out with cooperating institutions. This constituted the total research budget except for office and overhead expense. ASRE cooperated with many of the same universities that worked with ASH&VE and with ASHAE but, in addition, such names as Massachusetts Institute of Technology, University of Georgia, University of Kentucky and the University of Oregon appear.

New refrigerants present new opportunities and research has had to be continued on them and their usage. Historically we should mention that in 1912-13, ASRE sponsored the investigation by the U.S. Bureau of Standards to determine the latent heat of fusion of ice and also that, prior to 1920, ASRE raised the money that permitted the Bureau of Standards to carry out research and compile the Standard Tables of Properties of Ammonia which are in use today.

Additional research projects conducted by ASRE include: Preservation of Fish by Refrigeration; Economic Possibilities of Reverse Cycle Heating in the South; Enthalpy Studies on Food Products Above and Below Freezing; Low Temperature Insulation; The Effect of Moisture on Thermal Conductivity; Discoloration of Meat While in Storage; Temperature Range of Crystallization of Some Components of Animal and Plant Tissue; Methods of Recording Ultra-Rapid Changes in Temperature; and Heat Transfer of Condensing "Freon" in Horizontal and Inclined Tubes.

Realizing that research is the lifeblood of future progress and development, ASHRAE continued a vigorous program of encouraging cooperative research with universities and non-profit organizations. For the period July 1959 through June 1967, the Society expended just under three quarters of a million dollars in support of research. The current research commitments, which are now divided into research areas, include the following:

1. Effects of environment on humans, animals, plants, materials and processes
2. Mass transfer, including effects of moisture
3. Heat transfer and storage
4. Food preservation
5. Methods of heating, ventilating, refrigerating and air conditioning
6. Heat generation, including combustion
7. Climatology
8. Properties of solids, liquids, vapors and gases
9. Fluid flow
10. Noise and vibration
11. Control of systems and processes

By making these areas general in nature, the Research & Technical (R & T) Committees can use judgment and include almost any desired project in some category.

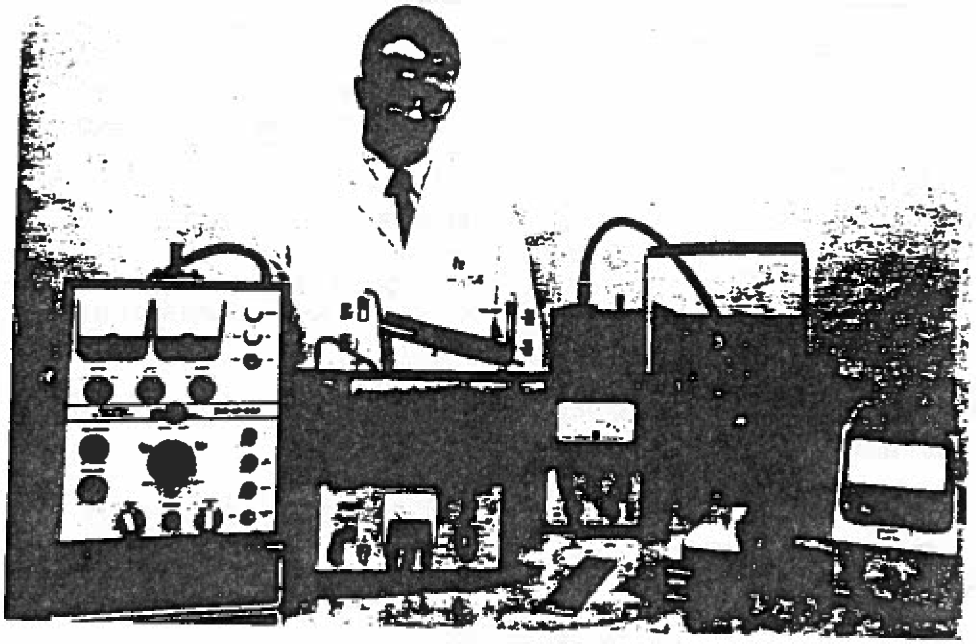
For the year 1966-67, ASHRAE sponsored 16 research projects at 13 institutions, 11 of which were universities. The actual research expenditure was $139,651 not including administrative, travel, headquarters, and overhead costs. During the 1967-68 year $134,000 was budgeted and committed for research projects. Expenditures on projects for 1968-69 are estimated at approximately $220,000 and the budget for 1969-70 is over $500,000. The research operation of the Society is guided by the R & T Committees, and by a Director of Research with the active support of 71 Technical Committees and 10 or more Task Groups.

The research needs of the Society change from year to year and no simple listing would be representative for any period of time. However, a listing of the 24 active research projects of ASHRAE for 1968-69 is presented because this furnishes a basis on which to make some historical observations as well as to indicate present patterns.

An examination of the list shows that Environmental Studies are continuing. Even though the Society has been working in this area since 1921, we need answers to many aspects of human behavior not only in relation to thermal environment but to other aspects of the associated environment. Not the least of these has always been man's response to humidity patterns in the air, and Society research provided precise formulations for the interaction and properties of low-pressure steam and air; this information made possible the accurate psychrometric charts and data on water vapor which are now in daily use.

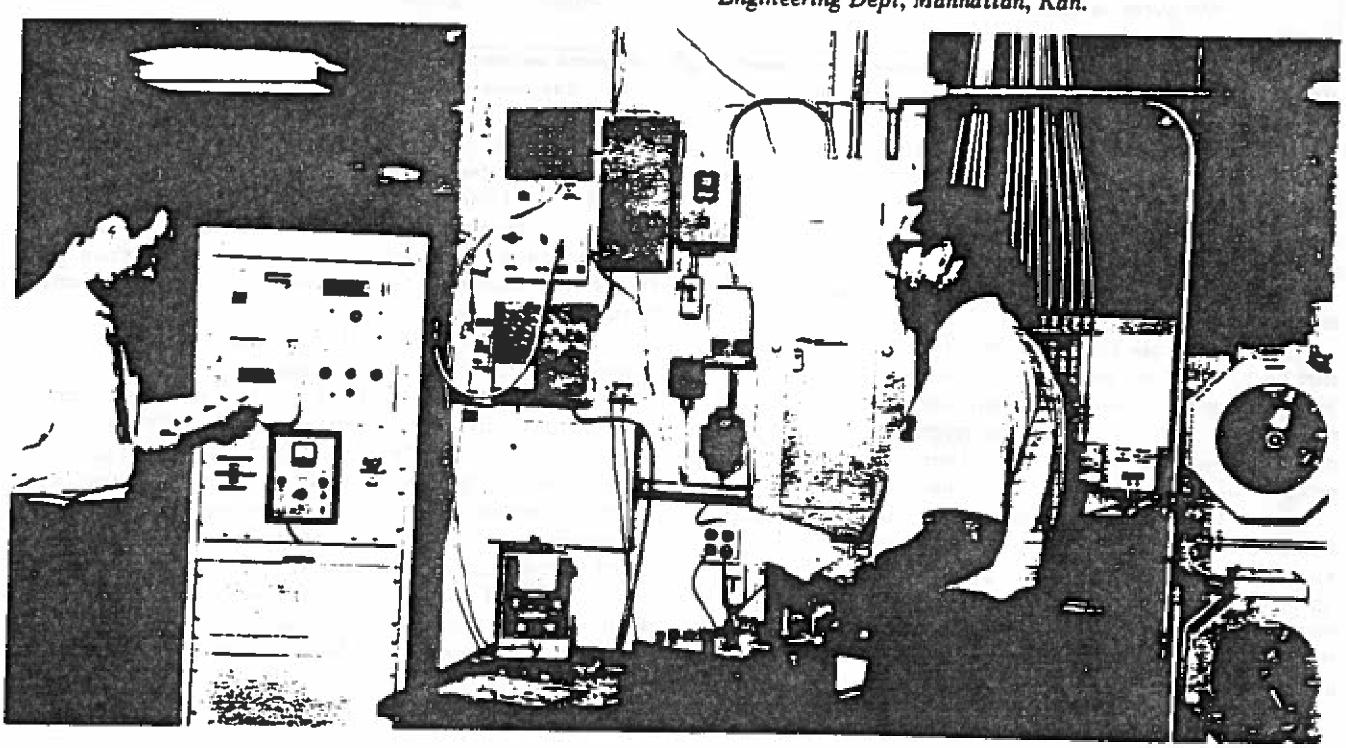
Studies are still being carried out on noise, under investigation by the Society since the 1930's. We still seek better means of controlling objectionable noises in our heating, refrigerating and air-conditioning systems and means of minimizing its transmission through pipes and ductwork.

Heat transfer and fluid flow problems present



Norman G. Ziesse, 1967 ASHAE-Homer Addams Award winner and a graduate student working on RP-60 – Soiling of Surfaces by Fine Particles, at Carnegie-Mellon University, stands behind equipment for particulate studies. Instruments from right to left are a photometer with pickup unit for light reflection measurements, an electrometer for sensitive current measurements, a small 2500 volt supply, and a larger kv power supply. The photometer is used to evaluate light scattered by samples of dust deposited on front-surface mirrors. The electrometer in conjunction with an HEPA filter measures electrical charge carried by dust. The HEPA filter is housed in the metal box to the right of the electrometer. The small power supply operates the front-surface mirror dust sampler (not shown) while the larger power supply is used to charge dust particles. A manometer, employed in airflow measurements, stands in the background over the small power supply

This photograph shows a student (left), and the project supervisor, at the data recording and control center of the test room used in ASHRAE Research Project RP-55 – Air Distributing Ceilings, at Kansas State University, Mechanical Engineering Dept, Manhattan, Kan.



ACTIVE RESEARCH PROJECTS

ASHRAE ENVIRONMENTAL STUDIES
Kansas State University

DYNAMIC RESPONSE OF A REFRIGERATION EVAPORATOR
University of Illinois

NOISE CONTROL IN LIQUID DUCT SYSTEMS BY ACTIVE ELEMENTS
University of Arizona

AIR DISTRIBUTING CEILINGS
Kansas State University

HOT-WATER AND STEAM-HEATING-SYSTEM RECOVERY FACTORS
University of Illinois

DETERMINATION OF THE EFFECT OF THERMAL ENVIRONMENT ON PRODUCTIVITY AND LEARNING
Dunlap & Assocs Inc

THE THERMAL CONDUCTIVITY OF FOODS
Purdue University

REFRIGERANT FORCED CONVECTION CONDENSATION INSIDE HORIZONTAL TUBES
Massachusetts Institute of Technology

MODIFIED MICRO-CLIMATES TO REDUCE HEAT STRESS IN DAIRY CATTLE
University of Arizona

FIELD STUDY OF LOAD PROFILES AND ENERGY REQUIREMENTS FOR HEATING AND COOLING BUILDINGS
General American Transportation Corp
University of California at Los Angeles
Ohio State University
Pennsylvania State University

EFFECT OF INNER-SURFACE AIR VELOCITY AND TEMPERATURE UPON HEAT GAIN AND LOSS THROUGH GLASS FENESTRATION
University of Florida

TRANSPORT PROPERTIES OF REFRIGERANTS
Purdue University

HEAT LOSS THROUGH WINDOWS UNDER COMBINED PRESSURE AND TEMPERATURE DIFFERENCE
University of Saskatchewan

A CRITICAL ASSESSMENT OF HIGH-VELOCITY DUCT DESIGN INFORMATION
University of Texas

SOLAR HEAT GAINS THROUGH 3/8- AND 1/2-IN. GREY PLATE GLASS WITH INDOOR SHADING
University of Florida

FIELD STUDY OF AIR QUALITY IN AIR CONDITIONED SPACES
Arthur D. Little Inc

ROOM AIR DISTRIBUTION PERFORMANCE
Kansas State University

THERMAL TRANSPORT STUDIES IN POROUS MEDIA
University of Colorado

SOILING OF SURFACES
Carnegie-Mellon University

A STUDY OF COMFORT, HEALTH AND LEARNING IN SCHOOLS WITH DIFFERING THERMAL CONDITIONS
Dunlap & Assocs Inc

AIR-CONDITIONING SYSTEM CONTROL
University of Connecticut

continuous challenges as new materials, new manufacturing methods, and new refrigerants are developed. The development of better instrumentation has made it easier to obtain answers to pressing problems with greater sophistication.

In the area of control, modern systems-analysis has given a new tool to the engineering world. Application of computer studies to system optimization has given our engineers tools that did not exist 15 years ago.

Let us now ask the questions: Who are the individuals that have carried out our Society research? Which ones have been the greatest leaders? Which ones have contributed most significantly to the various programs? Actually their number is legion and when this author was faced with the problem of picking a dozen or so names from the hundred or more distinguished individuals who have made really significant contributions to the Society's store of knowledge, the hopelessness of making a fair selection was obvious. The Society, itself, has honored many of its great members and perusal of ASHRAE TRANSACTIONS over the years will readily bring to light these distinguished individuals.

In this unnamed group are found great educators and industrialists, distinguished engineers and scientists and, among them and always supporting them, the Society officers, committee chairmen and members who have given unstintingly of their time, money, and knowledge to further Society progress in research. Many of them have passed on, but with the rapid growth that our Society has had, an even greater number of them actively continue their efforts to further our work.

Can ASHRAE on its 75th Anniversary be proud of its research contributions? Without question the answer is yes. Our industry is one of the most dynamic of modern times, it serves not only the comfort and well-being of man but also provides for man's welfare by its developments in food preservation, storage, and distribution. That these areas can function smoothly today is possible because of sound engineering and technical knowledge, much of which is based on research and the creations of standards, in all of which ASHRAE has been a true leader. ASHRAE can justifiably feel proud of its 75 years in research, much of which has made possible its many contributions to human welfare and comfort.

ASHRAE Standards Influence

J.R. CHAMBERLAIN
Fellow ASHRAE

TO present a history of ASHRAE Standards, it is necessary to review the origin of standards, *per se*. It is possible to be awed by the various scientific societies and trade associations, each with its own specialized standardization or simplification program. Without standards, any design tends to create new pieces and parts to be perpetuated, to increase costs for inventory and to confuse purchasers.

There are two broad classes of industrial standards: (1) Technical Standards – those which define the product in terms of size, shape, color, composition, quality or performance and which may be applied to processes, material specifications and test methods, including safety; and (2) Managerial (Procedural) Standards – those concerned with accounting and personnel systems. Standards of either class may apply to a single company or to an entire industry and may be national or international in scope. Individual companies, trade associations, technical societies, government agencies and the armed services, all sponsor standards.

Another class covers the accepted Standards of Measurement, which are reduced to absolute units of length, mass and time. These will become more important to engineering when the metric system is utilized worldwide.

Standards are the base of mass production; the contribution by the United States in this field through the use of standards is now history. Also, the use of standards improves the American economy for many reasons. Standardization on the company level is an accepted basic tool in manufacturing, accounting and purchasing. We tend to take, as a matter of course, the many items in commerce in everyday use, which are the result of standardization.

Among the first to recognize the desirability for standardization and simplification of industrial products was former President Herbert Hoover, Honorary Member of ASHRAE, who, in 1919, became president of the American Engineering Council, predecessor of the American Standards Assn (ASA), now the United States of America Standards Institute (USASI). Later, he continued to evidence his interest in standardization as Secretary of Commerce. The standards he espoused include electric light sockets, nuts and bolts, and plumbing fixtures. Standards today number in the thousands, most of which have been established on an entirely voluntary basis through a body, such as USASI, the American Society for Testing & Materials (ASTM), or the Society of Automotive Engineers (SAE), and others.

The heating, refrigeration, ventilation and air-conditioning industries are concerned with two types of standards. One type is produced by trade associations – Air-Conditioning & Refrigeration Institute (ARI) and Assn of Home Appliance Manufacturers (AHAM), formerly a part of National Electrical Manufacturers Assn (NEMA). The second type of standard is promulgated within the framework of technical and scientific societies, such as ASHRAE. Historically, it seemed that ASHRAE tended to move slowly from 1919 to 1930, but we do find a Tentative Code for the Regulation of Refrigeration Machines and Refrigerants issued in 1919 by the American Society of Refrigerating Engineers (ASRE). This code is the forerunner of USA B9.1-1964, ASHRAE Standard 15-64

Even before President Hoover's time, the refrigeration industry realized the importance of standardization and made an attempt at it in 1888 and 1889. In a paper entitled Twenty Years Ago[1] read by Thomas Shipley at the 20th Anniversary Meeting of ASRE at the Hotel Astor in New York City, December 2, 1924, it was stated:

"It was necessary to arrive at some general agreement, as to the condition under which it was proper to base guaranteed capacities of plants. It was also necessary to publish and make generally known this information relating to the dimensions and capacities of Refrigerating and Icemaking Plants. This was to prevent the continuance of the practice, then in vogue, of making statements to the effect that the Industry was surrounded by mysteries and secrets known only to the person spreading the propaganda, or to the Company he represented – which was an effort to obtain business by fear and intimidation, instead of merit. What was needed was an admission by men having proper authority from leading Companies engaged in the Industry – 'that each could produce a plant that would perform as guaranteed.' "

With this objective in view, refrigerating and icemaking manufacturers in the United States founded, on February 3 and 4, 1903, the Ice Machine Builders Assn of the United States, the forerunner of the Refrigerating Machinery Assn (RMA – 1919), the Air-Conditioning & Refrigerating Machinery Assn (ACRMA – 1940), and ARI (1953). The first action of standardization was for Ice Cans, which established dimensions for 50-, 100-, 200-, 400-, and 500-lb ice cans, the gauge of the material and construction. Their next standardization was the conditions under which a standard – or a unit – ton of refrigeration should be calculated, 15.65 to 185 psig (0 to 95.5 F) for ammonia.

The Ice Machine Builders Assn of the United States also established standardization on component parts of systems and surfaces and decided to build a plant on the premises of one of the member companies and to run tests. The objective of the tests was to determine a basis by which such plants should be rated and to establish by actual operation a set of conditions upon which could be safely based a unit ton of refrigeration. The first tests to determine the Standard Ton of Refrigeration were run in York on September 16 and 17, 1903. These tests were

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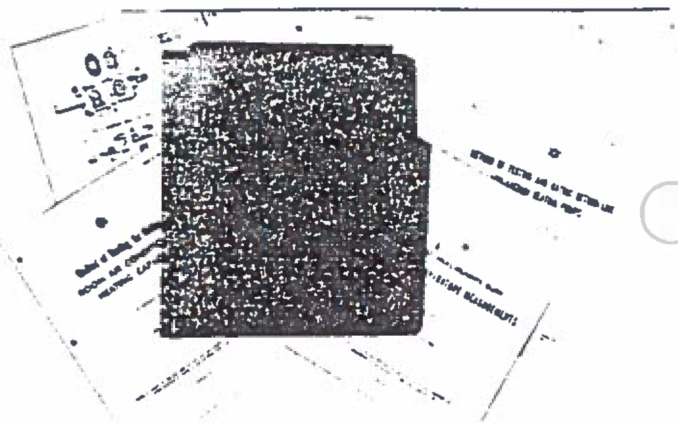
Living Conditions



published in an article entitled Report of Special Tests Made to Determine the Actual Work Accomplished by the Refrigeration Machine under Conditions such as Ordinarily Prevail.[2] (This is the forerunner of ASHRAE Standards 14-67 – Methods of Testing for Rating Positive Displacement Condensing Units; and 23-67 – Methods of Testing for Rating Positive Displacement Refrigerant Compressors.) Soon after this, ASRE came into being. At least half of its charter members were associated with the Ice Machine Builders Assn.

Thus, the separation of the function of a trade association and a scientific society was accomplished and each gravitated to its proper sphere, although admittedly there were some common members as is the case today.

A trade association standard specifies what should be included to constitute good practice and what parts should be included, such as standard ratings, testing, design and construction, safety devices, air or water quantities and velocities. A trade association standard should declare what the industry voluntarily agrees is the minimum equipment and basis of performance for a unit or system.

A technical society provides the necessary technical standards, to which trade association standards refer for such items as test methods, instruments and accuracy, by which testing is accomplished to provide ratings or performance and, in addition, define and list the terms used and data to be recorded.

Either type standard must avoid specific reference as to how a machine is to be designed. Neither should limit a design nor alter the ability to create unique and improved products. Both should state that equipment produce required results and be safe within accepted standards.

Little standardization occurred in our industry until RMA came into being. The American Society of Heating and Ventilating Engineers (ASH&VE) referenced some standards having to do with heating boilers. ASH&VE concentrated more on research in the heating and ventilating field and recorded much of it in TRANSACTIONS, and finally published these data in the ASH&VE GUIDE.

RMA found a situation in the rating of refrigerating compressors that was intolerable, especially because "Freon" had just been invented and there were some trends to use other refrigerants than ammonia. In 1935, ASRE joined with NEMA, RMA, ACMA (afterwards ACRMA) and ASH&VE to form the Joint Committee on Rating Commercial Refrigerating Equipment. This committee, representing the industry, developed several ASRE Standards (revised, these standards are still in effect). The Joint Committee served an important function and established what is now the basis of some ASHRAE Standards on refrigeration. Some notable members of the Joint Committee were L.S. Morse, Glenn Muffly and Frank H. Faust, all Presidential Members.

ASHRAE, in its efforts at standardization, strives to produce performance standards. The obsolete specification standard impedes progress because it prescribes specifics and prevents the utilization of improved techniques, materials and methods, which should result in lower cost and higher quality. Performance standards are concerned with results rather than manner, thereby safeguarding the public interest.

Among the first and prominent ASRE Standards is the B9.1 Safety Code for Mechanical Refrigeration (ASHRAE designation 15-64). This code is recorded in Refrigerating Engineering, Vol. 20, No. 5, November 1930. A safety code, of necessity, must be a type of specification standard; however, to keep it current, it must, under USASI procedure, be reaffirmed or revised every three to five years and have a standing Interpretations Committee. Code B9.1 was first issued in 1930 and revised in 1933. In 1939, it was enlarged and made more comprehensive to include the then new R12. In 1945, work was started on a complete revision and simplification of B9, published in 1950. This code was resolved by committees of ASRE, ASH&VE and ARI and was finalized under ASA procedures. Thus, both ASRE and ASH&VE became jointly active in standardization, although ASRE was the sponsor. Subsequent issues of B9 were published in 1953, 1958 and 1964. Shortly, another revision will be presented to ASHRAE for approval under USASI procedures.

The importance and recognition of the B9.1 Safety Code demonstrates the objectives of the early Ice Machinery Builders Assn. This code provides a basis for manufacturers to build equipment that will be acceptable to the various city and state authorities, a majority of whom have adopted B9.1 by reference. The consumer is best served by mechanical refrigeration equipment which conforms to the B9.1 Safety Code.

Appended to this article is a current list of ASHRAE Standards. These have filled a real need in our industries to ensure equitable quality and performance of equipment. Note that some of these are also USASI Standards.

All Society Standards are formulated and approved under the supervision of the Standards Committee. All are under constant review and revision. The numbers indicated for each Standard reflect the ASHRAE designation and the year in which the Standard was issued or revised. Availability of new Standards is announced by notice in ASHRAE JOURNAL.

Current List of ASHRAE Standards

12-58 Refrigeration Terms and Definitions (USA B53.1 – 1958)

13-53 Methods of Rating and Testing Home Freezers (USA B38.3 – 1955)

Method of Computing Food Storage Volume and

Shelf Area of Automatic Household Refrigerators (USA B38.1 – 1955)

American Standard Test Procedures for Household Electric Refrigerators [Mechanically Operated] (USA B38.2 – 1955)

14-67 Methods of Testing for Rating Positive Displacement Condensing Units.

15-64 Safety Code for Mechanical Refrigeration (USA B9.1 – 1964)

16-69 Method of Testing for Rating Room Air Conditioners

17-66 Method of Rating and Testing Refrigerant Expansion Valves (USA B60.1 – 1950)

18-62 Methods of Testing for Rating Drinking Water Coolers with Self-Contained Mechanical Refrigeration Systems

20-60 Methods of Testing for Rating Remote Mechanical Draft Air-Cooled and Evaporative Condensers

22-61 Methods of Testing for Rating Water-Cooled Refrigerant Condensers

23-67 Methods of Testing for Rating Positive Displacement Refrigerant Compressors

24-61 Methods of Testing for Rating Liquid Coolers

25-68 (Revised – 25-56) Methods of Testing for Rating Forced Convection and Natural Convection Air Coolers for Refrigeration

26-63 Recommended Practice for Mechanical Refrigeration Installations on Shipboard (USA B59.1 – 1964)

28-57 Method for Testing Capillary Tubes

29-63 Methods of Rating and Testing Ice Makers

30-60 Methods of Testing for Rating Liquid Chilling Packages

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MILESTONES in AIR CONDITIONING

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WHERE does the history of air conditioning begin? With the cave man who thousands of years ago modified his personal climate by nurturing the first fire? With the Romans who so ingeniously engineered ventilating and panel heating into their baths? With the unsung pioneer who first cooled a room with air cascading over a suspended tub of ice?

These questions remind us that the art and industry of air conditioning did not spring suddenly from the brain of a single genius or from the inspirations of a line of distinguished inventors. They evolved falteringly and gradually from their predecessor arts and crafts – heating, ventilating, cooling and cleaning. The development of scientific theory, credible engineering data and practical how-to-do-it technology was just getting underway when the American Society of Heating and Ventilating Engineers (ASH&VE) was born in 1894, even though the underlying principles had started to evolve four centuries earlier.

ROOTS IN THE PAST

The remarkable Leonardo da Vinci had built a ventilating fan at the end of the 15th century.[1] Robert Boyle enacted his famous law in 1659, and John Dalton took his turn in 1800. The Scottish physician Dr. William Cullen in 1775 pumped a vacuum in a vessel of water to make ice. And a few years later our own Benjamin Franklin wrote his treatise on Pennsylvania fireplaces, detailing their construction, installation and operation with elaborate illustrations.[2]

During the 19th century the techniques of warming and ventilating were progressing well. Fans, boilers and radiators had been invented and were in common use. In 1815, Robertson Buchanan, a civil engineer in Glasgow, published his definitive text on heating and ventilating, followed nine years later by the landmark manual of Thomas Tredgold.[3] In 1895, Professor Rolla C. Carpenter of Cornell University (later ASH&VE's third President), climaxed the many textbooks published here and abroad with his authoritative Heating and Ventilating Buildings.

As installations multiplied and were debugged and improved, pioneers of the new steam and hot water heating systems were no longer compelled to design and fabricate their own furnaces, boilers, fans and radiators; a manufacturing industry was growing up to satisfy their needs. Companies familiar to our own generations were established – Babcock & Wilcox, H.B. Smith, Crane, and Walworth, as well as a host of others whose names have long since faded from the scene.[4] The stage was set for the advent of air conditioning.

Refrigerating technology was not very far behind. Dr. John Gorrie, a physician in Charleston, S.C., invented a dense air compression machine in 1849. In France, Ferdinand Carré in 1851 designed the first ammonia absorption unit. In 1853, Professor Alexander Twining of New Haven, employing the unsuccessful invention of Jacob Perkins, produced 1600 lbs of ice a day with a double-acting vacuum and compression pump using sulfuric ether as the refrigerant.[5] The enterprising Daniel L. Holden, who later became a charter member of the American Society of Refrigerating Engineers (ASRE), improved the Carré machine, designed and built reciprocating compressors, and applied them both to icemaking, brewing and meat packing.[6] In 1872, David Boyle invented the ammonia compression machine, producing ice with it the following year.[5]

Manufacturers soon organized to meet the rapidly growing demand for refrigeration equipment. The Frick Co was established in 1853, followed by a long line of famous ice machine concerns.[7] – Vilter, York, De La Vergne, Vogt, Carbondale, Creamery Package, Kroeschell and Brunswick – all prior to 1904, the year ASRE was founded. By then many hundreds of compression and absorption machines were in operation. While most of them made ice or cooled produce,[8] a few had already been applied to the chilling of air which was blown over brine or direct expansion pipe coils.

Toward the latter half of the century, accompanying the growth of the textile industry in New England, invention and art went hand in hand to develop methods for

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moistening air to overcome the manufacturing problems caused by low humidity. The same period saw the construction of rudimentary washers and precipitators for air cleaning. Devices for measuring temperature, humidity, pressure and flow of air — actually invented centuries before[1] — were perfected into truly scientific instruments well suited for determining equipment and system performance. Fan companies started to appear — Sturtevant in 1860, followed by Buffalo Forge, Huyett & Smith (ancestor of American Blower), and New York Blower.

THE "GAY 90'S"

So it was that, in 1894, all the ingredients essential to the technology later named air conditioning were maturing rapidly. A market for humidifying and evaporative cooling, already existing in the textile mills, was poised to explode into many other industries.[9] Experimental installations of summer cooling had brought experience and confidence to a few courageous engineers. Young but progressive manufacturers stood ready to exploit the integration of heating and cooling, humidifying and dehumidifying, air moving and air purification. Yet several elements vital to the creation of a sound and expanding industry were still missing. Among these were:

1. Definitive rational theory to permit calculation of performance and prediction of results.
2. Adequate physical, thermodynamic and fluid dynamic properties of air, water, brines and refrigerants.
3. Authoritative information on heat transmission involving combustion, conduction, convection, radiation, evaporation, condensation and other pertinent processes.
4. Credible performance information for manufactured equipment.

It is hard for the mechanical engineer in today's silver-platter technical environment to conceive of the difficulties surrounding the engineers of the 90's. Even though heating calculations had been rationalized 50 years before, data on transmission coefficients were sparse and subject to errors of 25 to 50%. Information on air and water friction in pipes and on properties of brine and ammonia[10] was in similar disarray. Performance data on equipment were mostly educated guesses, often with generous measures of optimism thrown in. Hearsay governed the design conditions specified for comfort and for industrial processes, while dubious records determined the outdoor conditions, including wind and solar effects, which constituted the major heating and cooling loads. And, of course, reliable psychrometric tables and charts did not exist.

A major purpose in the establishment of both ASH&VE in 1894 and ASRE in 1904 was to bring together groups of engineers who would work together to fill the needs of the time and expand their technology for the future.

With 75 charter members, ASH&VE was off to a promising start in September 1894, adopting an official name, constitution, bylaws, and a temporary slate of officers.[11] The eight papers presented at the Annual Meeting in January 1895, covered in the first TRANSACTIONS,[12] were concerned entirely with heating and ventilating. The program also included a series of Topical Discussions, among them a learned exchange about the future of electric heat, which concluded that it was too expensive even for trolley cars! Discussion of metal vs wooden cold air conduits was cut off after it was reported that galvanized iron had generally replaced wood. A lengthy debate sparked by incoming President Stewart A. Jellett as to whether steam heating contractors and engineers should get paid for preparing plans and specifications for architects signalled the start of an argument about conflict of interest which was to rage for many years.

Only 10 years later, in 1904, a group of about 70 refrigerating engineers organized ASRE and elected as temporary chairman John E. Starr, well known consulting engineer of New York.[6,13,14] Although at the first Annual Meeting held the following year, the papers relating to ice machines and cold storage were primarily of contemporary interest, newly-elected President Starr, in a lyrical inaugural address highlighting the fields in which refrigeration had become essential, took off into the wild blue yonder and predicted refrigeration's future growth into textiles, chemicals, tobacco and mines, as well as the many applications for relieving the discomfort and suffering of human beings. Then in a more serious vein, he voiced what became a guiding principle for the new organization: "We have undertaken the responsibility of speaking with authority, of finding the truth and proclaiming it, and a critical world will hold us to our task or pass us by as unworthy."

HISTORY IS A STORY OF MEN

The history of an art and an industry is the story of the men who made the impact — the engineers, scientists, educators, contractors, manufacturers, wholesalers and retailers, service and support personnel. In any new undertaking, when the number of producers and consumers is small, the creators and doers operate principally as individuals. Then as the art and the industry proliferate, the entrepreneur performs less as an individual and more as a leader of a team. At the beginning there are often opportunities for a few great leaps forward toward the establishment of a sound science and technology. Later the opportunities for novelty and improvement diminish in both glamour and dimension, just as they increase vastly in number because of the explosive growth in application and demand.

In a chronicle of this nature it is not practical to recognize the achievements of most of the many men who built the art and industry of air conditioning. It must suffice to salute a few great individuals who early set the pace, and to discern the milestones established in later years by distinguished groups of men — the technical societies, the universities, the companies — who through their team efforts have made such a major impact upon our economy.

Of the men of stature, one of the most important consulting engineers in the early era, Alfred R. Wolff (1859-1909) never became a member of ASH&VE because the Society permitted salesmen to join! A charter member of the American Society of Mechanical Engineers (ASME) founded 1880, Wolff[15,16] and his organization designed the heating and ventilating systems for more than 100 prominent buildings extending across the continent. His accomplishments during the period 1888-1909 included such diverse structures as the Waldorf-Astoria Hotel, Gimbel Brothers in Philadelphia, Bank of Montreal, St. Patrick's Cathedral, and the New York Public Library, besides theaters, clubs, hospitals, residences and court houses. Very importantly, he put the calculation of heating loads on a scientific basis by combining German theory with the practical technology developed in this country.

Wolff pioneered several early comfort cooling installations,[17] including an ice melting system for Carnegie Hall

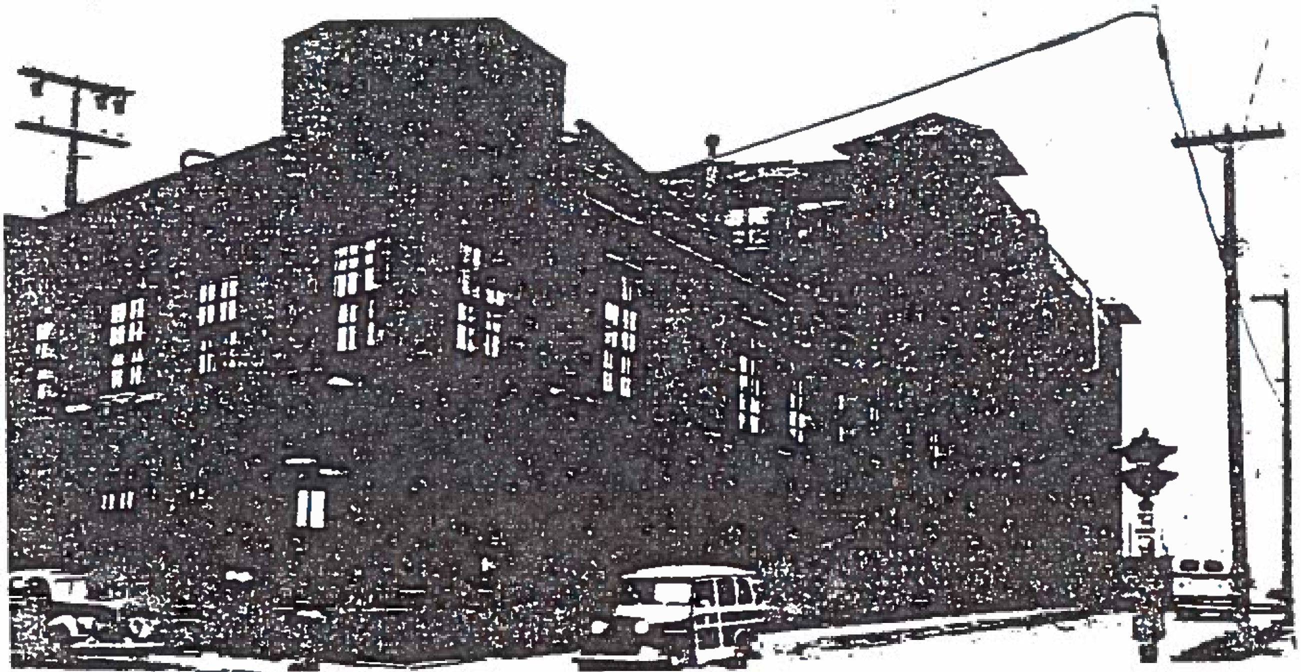

Fig. 1 The first scientifically engineered air-conditioning system was installed in 1902 in the Sackett-Wilhelms lithographing and printing plant in Brooklyn, N.Y.

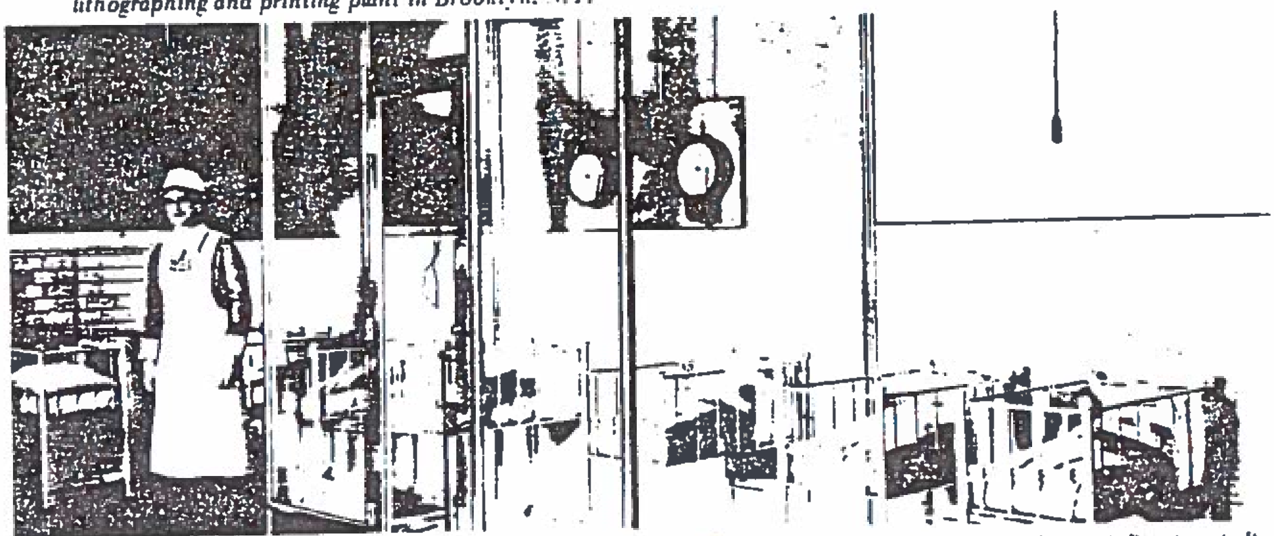

Fig. 2 Air conditioned premature baby ward installed in 1913 in the Allegheny General Hospital, Pittsburgh, Pa.

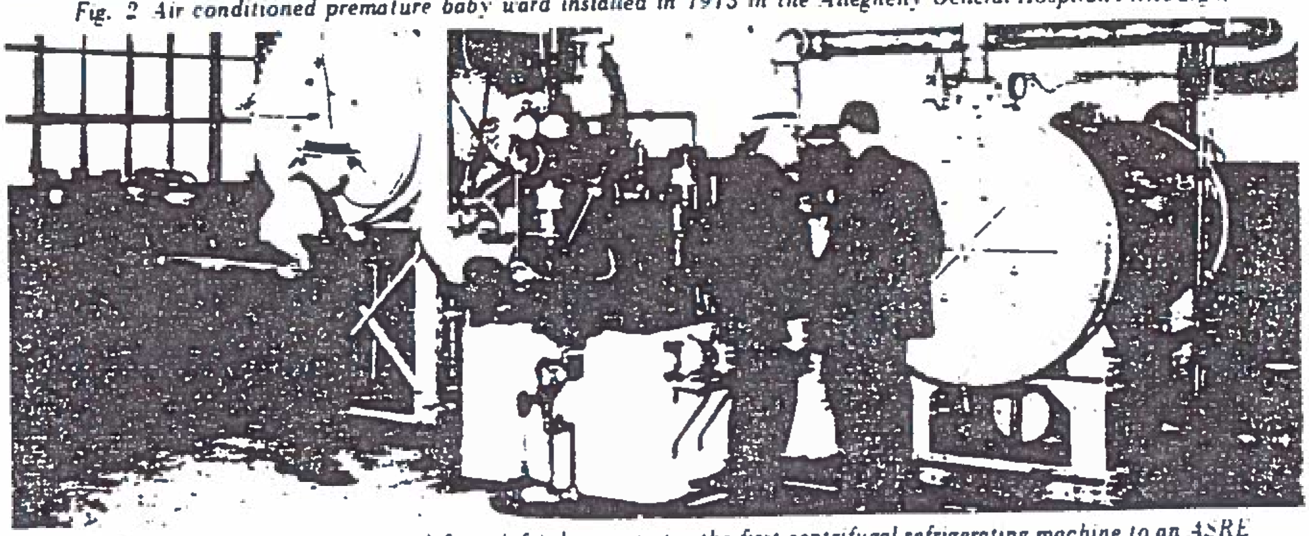

Fig. 3 Willis H. Carrier (second from left) demonstrates the first centrifugal refrigerating machine to an ASRE member in 1923

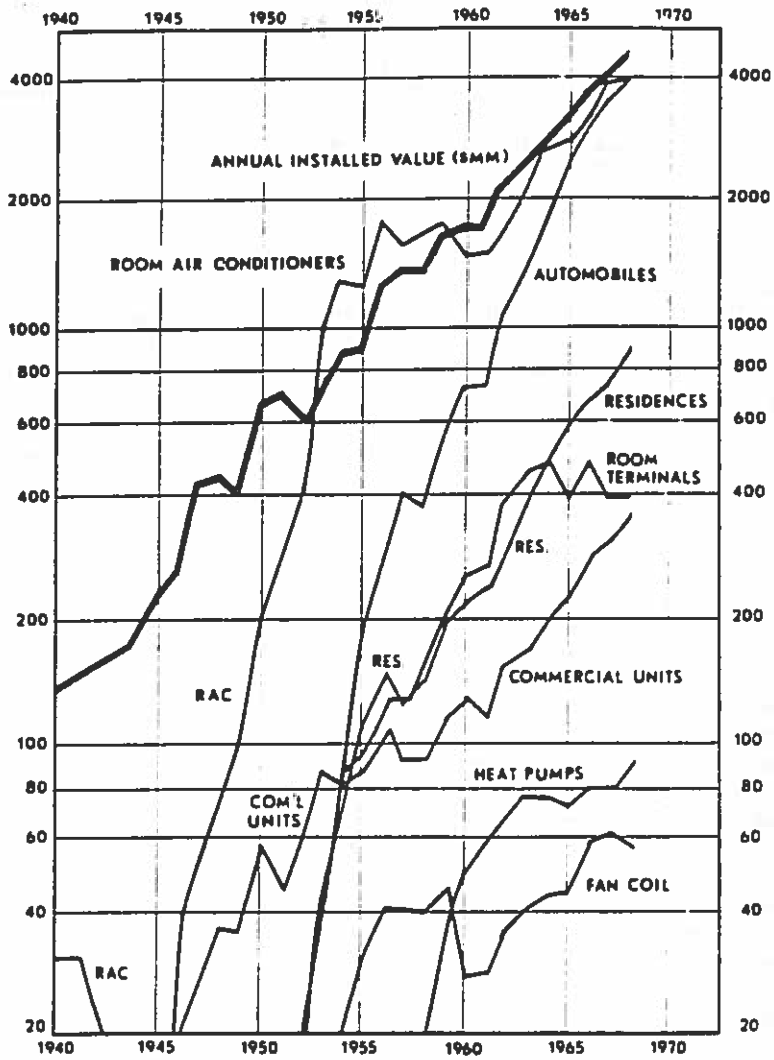

Fig. 4 Growth of the air-conditioning industry since 1940. Top curve: total installed value of all air conditioning in the United States (except transportation), millions of dollars per year; all other curves: thousands of units sold annually in each category

(1890), a brine coil system for the dissecting room at Cornell Medical Center (1899), and a system for preserving art objects in the Metropolitan Museum (1907). Most famous of all was the brine coil system, designed jointly in 1902 with Henry Torrance, Jr. (charter member of ASRE and President in 1914) for the New York Stock Exchange,[18] which operated successfully for 20 years.

In the field of textile mill air conditioning, the recognized pioneer is Stuart W. Cramer (1868-1950), versatile engineer, contractor, inventor, author, business tycoon, politician and civic leader, credited with designing or equipping nearly one-third of the mills in the south.[19] Among some 60 patents were a humidity indicator and controller, atomizing nozzles for humidification, and spray-type central station apparatus. He is particularly remembered as the man who introduced in 1906 the term "air conditioning" when, at a convention of the American Cotton Manufacturers' Assn,[20] he explained how control of the moisture in the air necessarily meant control of the moisture content in the product. Upon his retirement from business in 1918, the G.M. Parks Co purchased his interest and organized Parks-Cramer Co.

WILLIS H. CARRIER

Towering above his contemporaries was the "Father of Air Conditioning," Willis H. Carrier (1876-1950, President of ASRE 1927, ASH&VE 1931) who through his brilliant analytical and practical accomplishments contributed more to the advancement of the developing industry than any other individual.[1] Employed by the Buffalo Forge Co after graduating from Cornell in 1901. Carrier realized that because of the inaccurate data then available, satisfactory installations could not be made without the use of excessive safety factors. Within a year, he had developed formulas for optimizing the application of forced-draft boiler fans, conducted tests and developed multi-rating performance tables on indirect pipe coil heaters, and set up the first research laboratory in the heating and ventilating industry.

In 1902, faced with a challenge from consulting engineer Walter S. Timmis (President ASH&VE, 1919) to solve the lithographic industry's perennial problem of poor color register with every change in the weather, Carrier designed, shop tested and installed for the Sackett-Wilhelms Lithographing & Printing Co in Brooklyn, the first scientifically engineered year-round air-conditioning system, providing the four major functions of heating, cooling, humidifying and dehumidifying (Fig. 1).

During the following two years Carrier adapted atomizing nozzles and developed eliminators for air washers to make them suitable for controlling the dew point of the air by heating or chilling the recirculated water. This invention opened the door to year-round air conditioning in more than 200 industries.

In December 1911, Willis Carrier presented at the Annual Meeting of ASME his epoch-making paper, Rational Psychrometric Formulae,[21] which related dry-bulb, wet-bulb and dew point temperatures of the air as well as its sensible, latent and total heat, and enunciated the theory of adiabatic saturation. These formulas, together with the accompanying psychrometric chart, became the authoritative basis for all fundamental calculations in the air-conditioning industry. A companion paper[22] explained the practical side of the growing technology (Fig. 2).

In 1915 at the start of World War I, when Buffalo Forge decided to devote its entire effort to manufacturing, Carrier and six associates founded the Carrier Engineering Corp as a sales, engineering and contracting organization with a paid-in capital of $32,600. A large share of the credit for the successful expansion of the company – and with it the infant industry – goes to Carrier's talented co-founders.* Twelve years later, with no additional financing, the net worth of Carrier Engineering had grown to $1,350,000.

Among Willis Carrier's most notable inventions was the centrifugal refrigeration machine (Fig. 3) in 1922 which, together with the development of non-hazardous low pressure refrigerants, made practical and economical the chilling of water for large and medium-sized commercial and industrial air-conditioning applications.[20, 23, 24] Another invention was the conduit Weathermaster induction system for multi-room buildings, initiated in 1937 and since installed in hundreds of office buildings, apartments, hotels and hospitals.[25] A spectacular personal contribution to the war effort during World War II was his supervision of the design, installation and start-up of the system at the National Advisory Committee for Aeronautics (NACA) in Cleveland for cooling 10,000,000 cfm of wind tunnel air down to –67F. Operation of the mammoth 21,000 hp direct expansion plant commenced in the spring of 1944 when Willis Carrier was 68 years old.

Many other prominent men advanced the art during the first quarter century after the founding of our Society. A.M. Feldman, a consulting engineer in New York, is remembered for the air-conditioning system he designed in 1906 in the Kuhn, Loeb & Co bank building.[26] Beginning in 1903, Walter L. Fleisher (1880-1959) extended the frontiers of both comfort and industrial air conditioning through his versatile roles of design and consulting engineer, contractor and manufacturer. Active in both Societies, Fleisher became President of ASH&VE in 1941 and received the F. Paul Anderson Award in 1953.

The roster of the great and near-great is a long one, their accomplishments were prodigious, and it is regrettable that each one cannot be acknowledged in this review.

The years following Willis Carrier's memorable paper in 1911 saw wholesome air conditioning growth in industry, particularly in cotton, silk, rayon, tobacco, paper, pharmaceuticals, candy and printing, but there was relatively little activity in comfort cooling. World War I presented some unusual challenges, few in number but crucial in solving production bottlenecks and assuring quality in the manufacture of shrapnel fuses, rifles, chemicals and aircraft.

*These men were: J. Irving Lyle, President ASH&VE, 1917; Alfred E. Stacey, Jr., President ASH&VE, 1949; L. Logan Lewis, President ASRE, 1931; Edward T. Murphy; Edmund P. Heckel; and Ernest T. Lyle.

ASH&VE'S SILVER ANNIVERSARY

With the arrival of ASH&VE's silver anniversary in 1919, the Society had passed the thousand mark in membership, established 11 local chapters stretching from New York to Kansas City, and was operating 20 working committees. Heating and ventilating were still its first love – witness the TRANSACTIONS of that year which listed 19 papers on those subjects, compared with two on air cleaning and only one on air conditioning.

The 25th anniversary year marked a momentous event in the Society's history – the establishment of a Research Bureau utilizing the laboratory facilities of the Bureau of Mines in Pittsburgh. For despite the industry's giant strides since 1894, key basic information on infiltration, heat losses through building materials, ventilation requirements, and performance and sizing of direct radiation and piping were still sorely needed by the profession. In authorizing the new venture, the ASH&VE Council adopted a "canon of ethics": the laboratory was not to conduct tests, experiments or research for compensation, in order that the "activities of the Research Bureau shall be above reproach."[27, 28]

In 1946 the research activity was moved into its own laboratory facilities in Cleveland, where it operated until its closing in 1961 for economic reasons. ASH&VE was the only engineering society in the country to have its own research laboratory, and it had an illustrious record of achievement spanning 42 years. During those years and since, the Society's research programs, both at the laboratory and through many sponsored projects at universities, added enormously to the industry's inventory of basic knowledge.

COMFORT COOLING GETS OFF THE GROUND

Comfort air conditioning made its first breakthrough in motion picture theaters. Triggered in Chicago in 1919-20 by two Balaban and Katz houses employing CO_2 machines, and in Los Angeles in 1922 by Grauman's Metropolitan using an ammonia compressor, the new centrifugals provided the impetus for the Rivoli, Paramount and Roxy Theaters on Times Square. By the end of the 20's, several hundred theaters had been air conditioned throughout the country.

The first centrifugal which had started operation at the Onondaga Pottery Co in Syracuse in 1923[29] was followed by installations in the J.L. Hudson department store in Detroit, Madison Square Garden (for producing ice for skating as well as air conditioning), the engine room of the battleship Wyoming, and the House and Senate chambers in the U.S. Capitol.

Other milestones intensified the industry's new vigor. The two Societies undertook important new publishing responsibilities to inform and educate their members and the profession. The annual ASH&VE GUIDE and the monthly magazine Refrigerating Engineering which included the ASRE Journal were born in 1922. In 1923-24, the ASH&VE laboratory published a series of research results by Houghten, Yaglou, et al.[28, 30] which defined the effective temperature for normally clothed individuals at rest, and derived the so-called Comfort Chart. This Chart, revised in later years to reflect more accurate information, became the recognized industry standard on which specifications of indoor design conditions were based.

In 1929, ASRE celebrated its 25th birthday, and took stock of its many contributions to progress.[31]

A development of particular value to comfort cooling, which economically solved the problem of humidity control under varying load, was the system of air bypass control, invented in 1924 by L. Logan Lewis and improved by Fleisher.[20] Towards the end of the decade, General Electric introduced the first self-contained room air conditioner. Other influential milestones of the 20's included lightweight extended surface coils, and the first unit heater and cold diffuser.*

THE THREADBARE '30'S

During the first half of the 1930's the entire country was flat on its back in the midst of the great depression. The market boom which had just begun in air conditioning rapidly became a bust. Yet, even in the more difficult years, the competitive advantages resulting from air conditioning sufficed to maintain demand in several segments of the industry, particularly in retail trade. More importantly, this period saw the introduction of innovations which would have a profound effect upon the small commercial and, ultimately, the residential markets.

Leading the procession in 1930 was the development by Thomas Midgley, Jr. (du Pont) of the "Freon" refrigerants. Their safety and desirable properties made the small reciprocating compressor practical and economical for the commercial and residential markets. Soon manufacturers started to build room air conditioners using "Freon-12." Larger sizes of self-contained units followed, suitable for stores and restaurants. Shortly, manufacturers realized that direct sale to these classes of consumers could not possibly obtain them adequate market coverage at a profit. In 1932, Carrier created the first dealer organization, a pattern soon adopted by most other companies.[32]

Availability of the fluorinated refrigerants was equally advantageous to centrifugal compression which required only half the number of impellers for the same head as chlorinated hydrocarbons. Acceptance of the centrifugal principle for the larger tonnages was now so general that five more manufacturers entered the business.** Significant economies of space and materials were realized by the introduction of pressure-formed extended surface tubing in shell and tube exchangers, an invention by Walter Jones which represented a major advance for both centrifugal and reciprocating equipment.

There were several other noteworthy achievements during this decade. In 1931, Servel introduced its first lithium bromide absorption machine for residences. The same year, Carrier marketed a line of steam ejector cooling units for railroad passenger cars. The mid-30's saw introduction of the heat pump by General Electric, the electrostatic air cleaner by Westinghouse, the high speed radial compressor by Airtemp, and activated carbon for odor removal by W.B. Connor.

The engineering societies were growing rapidly and performing important services for their members. ASRE published its first DATA BOOK in 1932 and, after years of joint effort with the American Standards Assn, launched its Safety Code for Mechanical Refrigeration,[33] truly the 10 commandments of the industry. In addition to many other research projects, ASH&VE continued its fruitful studies of human comfort, with special emphasis on the complex relationships of clothing, activity, perspiration rate and acclimatization under various indoor air conditions.

We see that the 30's were not so threadbare after all!

THE INDUSTRY AND WORLD WAR II

The war, as had the depression interrupted the industry's growth pattern in the many promising and unsaturated markets. But it proved one point conclusively: air conditioning was no longer a luxury. Although wartime regulations barred it from normal civilian use, military requirements were sufficient to keep busy a substantial part of the industry's engineering, manufacturing, installation and servicing manpower and machines.

Possibly 80% of productive capacity was devoted to regular products or to special designs for military purposes, with only about 20% conversion to unrelated armaments manufacture. The list of wartime uses is impressive, ranging from smokeless powder to stratosphere chambers, mobile trailers to Link trainers, and aircraft carriers to the Pentagon itself.[32,34] Developments advantageous to peacetime economy were air-cycle cooling for aircraft and the small dehumidifiers for bomb shelters, both now items of civilian production.

The end of the war marked a transition from the pioneering to the acceptance phase of the industry's growth cycle. Most of the uniquely creative milestones had been passed in the previous half century. The years to come were to be years of fulfillment – expansion of markets, improvement in products, and extension of the benefits of the new technology to millions of people throughout the world.

AIR CONDITIONING COMES INTO ITS OWN

Fig. 4 shows this growth graphically. In the last 20 years, the annual installed value of air conditioning at the consumer level has multiplied tenfold, reaching the astronomical expenditure of $4½ billion during the year 1968. The chart also dramatizes the expansion in the number of units sold in each of the major product categories. Except for room air conditioners, none of these products sold pre-war in any appreciable volume, and several of them were non-existent.

The growth rate of two of these products has been little short of spectacular. The number of central residential air-conditioning units installed each year has multiplied tenfold in the last 14 years. And it has taken only 10 years for automobile air conditioning to expand by the same amount.

In the last quarter century product technology has advanced by leaps and bounds. The air source heat pump and the large lithium bromide water chiller were important innovative breakthroughs right after the war. Then in the 50's came automobile air conditioners, rooftop heating and cooling units, and the small outdoor-installed ammonia absorption chiller. In the 60's we have seen introduction of new kinds of air purifiers, a vapor cycle aircraft cabin cooling unit, and a large capacity Lysholm rotary compressor.†

**Extended surface coils (1923): Aerofin Corp; unit heater (1922) and cold diffuser (1928): York Heating & Ventilating Corp. The original unit heater is on permanent exhibit at the Franklin Institute.*

***The five companies were: Ingersoll-Rand, Brown-Boveri, Trane, York and Worthington. Trane introduced the first direct-drive hermetic unit in 1938.*

†Air source heat pump: Drayer-Hanson; lithium bromide absorption chillers: Carrier; small ammonia absorption unit: Bryant; vapor cycle aircraft air conditioning: Carrier; Lysholm rotary compressor: Dunham-Bush.

Many more innovations come under the heading of product improvements or expansion of product lines. To name just a few from the enormous number of possible examples:

- Dual-duct central systems for office buildings
- Change from open to hermetic compressors from the smallest reciprocating units to large capacity centrifugals
- Resurgence of electric heating in all kinds of applications
- Use of heat pumps to reclaim heat in large buildings
- Application of electrostatic cleaners to residences
- Self-contained variable volume air terminals for multiple interior rooms
- Increasing use of total energy systems for large buildings and clusters of buildings
- Larger sizes of centrifugals, now over 5000 tons in a single unit
- Central heating and cooling plants for shopping centers, colleges, and apartment and office building complexes

By and large, however, the growth of markets represents the most remarkable phenomenon of the last two decades.[35] Immediately after the war the trend towards cooling new theaters, banks, stores, hotels and motels, hospitals and office buildings resumed and accelerated. A concentrated push into houses, apartments, factories and schools began about 15 years ago, yet these markets are still far from saturated. The experts estimate that in 1968 only 8½% of homes (both houses and apartments) had complete air conditioning, and only 27% had one or more room units. Public school classrooms, less than 9% saturated, represent another rapidly expanding market. We still have a long distance to go!

As far as the moon? Indeed! We have now reached the moon and are seeking further space conquests. For environmental control of astronaut and spacecraft – air conditioning in its most sophisticated form – has permitted man to surmount the hostile climates of moon and space, and made possible all of the significant manned missions beyond our planet Earth.

Our two engineering Societies, such dynamic factors in the industry's health and growth, constructed a milestone of their own just 10 years ago. Here was an example of people, technologies and commercial enterprises growing closer together in their mutually complementary activities. The merger of ASHAE and ASRE in 1959 to create the American Society of Heating, Refrigerating and Air-Conditioning Engineers was the happy and logical conclusion. (In 1954, ASH&VE changed its name to the American Society of Heating and Air-Conditioning Engineers – ASHAE.) ASHRAE in its 75th anniversary year can view in retrospect, and with considerable satisfaction, the many technical and commercial milestones in the creation of which its members have played so vital a part.

ASHRAE is on the move. The sands of time await its 25,000 footprints. The 21st century lies just ahead, and the opportunities for service will be limitless. The milestones of the future are bounded only by our vision and imagination.

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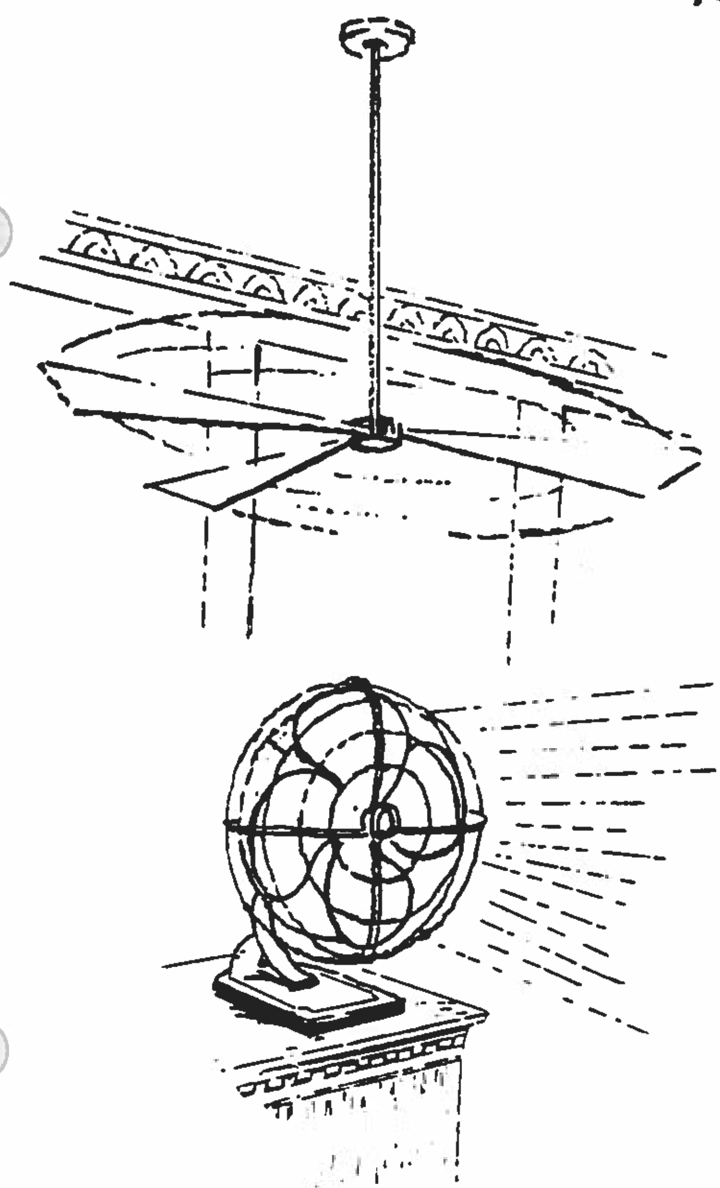
75 YEARS of VENTILATION

J.B. GRAHAM
Fellow ASHRAE



ON the ceilings of cliff dwellings in New Mexico one can find interesting primitive symbols drawn in the soot from fires built in the small cramped rooms perhaps 1000 years ago. These soot laden ceilings stand as evidence of inadequacies of the then current ventilation system. Today one can find soot marks around the outlet grilles of modern high-rise cliff dwellings. This not only indicates certain long range problems in ventilation, but as one seldom observes an interesting design drawn in present-day soot marks, it is apparent that there has been a general decline in the imagination and artistic ability of cliff dwellers.

According to ASHRAE HANDBOOK OF FUNDAMENTALS, ventilation is defined as the process of supplying or removing air by natural or mechanical means. Such air may or may not have been conditioned.

It is impractical to cover the entire history of ventilation in one article and, therefore, I will confine my remarks to that period covering the 75-year history of ASHRAE. For the most part, this period is reflected in ASHRAE TRANSACTIONS and ASHRAE GUIDE AND DATA BOOK. Although I refer to the Society as ASHRAE, it is quite obvious that I am also referring to the predecessor organizations.

In reviewing past ASHRAE publications, a new sense of the true significance of the Society was gradually developed. Heretofore, I used ASHRAE TRANSACTIONS as reference material and referred each time to specific papers for information. I also viewed ASHRAE TRANSACTIONS as a collection of individual technical papers without any great sense of continuity.

For this article I examined ASHRAE TRANSACTIONS and ASHRAE GUIDE AND DATA BOOK in chronological order and became intrigued by the new picture they presented. A sequence of related papers over a long period shows the shifting emphasis, the temporary rejection of new ideas which were contrary to popular practice at the time, and the gradual acceptance of new ideas and techniques. It is heartening to observe that, in

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spite of temporary aberrations, the general progress in ventilation practice has moved steadily in the direction of better use of fundamental data.

Specific landmarks in the history of ventilation are difficult to define since development has proceeded step by step and the work of each man is based on the work of his predecessors. In this field, we are not dependent upon the "bolt from the blue" discoveries of a few men but on the combined work of hundreds of men with each adding his contribution to the general fund of knowledge. It is one of the essential points of an article such as this to explain the impossibility of recognizing all the contributors to progress. The contributors are legion and their names are inscribed in the permanent records of the Society.

By hindsight, the macro-history of a technical development can be easily traced and each forward step placed in proper context but accurate evaluation of the micro-history at a given point in time is not always simple.

When a technical paper presenting new and original ideas (unfortunately not all technical papers fall into this category—and the wheel is periodically re-invented) is presented, it is difficult to make an immediate judgment on the significance, importance and scientific value of the engineering contribution that this paper will make over a long range term. This difficulty does not dismay engineers who are quite willing to comment immediately on the paper just presented. In ASHRAE, these comments are published in [illegible]SACTIONS for all posterity.

It is [illegible] to read comments which indicate an almost [illegible] foresight concerning the importance and significance [illegible] paper that has just been presented. Some ASHRAE [illegible] been able to listen to a technical presenta[illegible] place it in its proper context, and [illegible] accurate prediction of how this info[illegible] used to make significant changes in [illegible]. Furthermore, they point out with [illegible] the direction that future research and development [illegible] take. Some people are always well [illegible] and it is an interesting (and sometimes [illegible] to follow an original idea from its [illegible] general acceptance.

[illegible], there are some comments which [illegible].

[illegible] on the flat land near Colorado [illegible] snow capped mountain looming in [illegible] nced: "Yonder peak will never be [illegible] oday one can "scale" this peak by [illegible] a highway built all the way to the top of [illegible] is called, appropriately enough, "Pike's [illegible] with such gratuitous statements [illegible] on the characteristics of mountain [illegible] notoriety than similar comments [illegible] ASHRAE TRANSACTIONS in[illegible] which rival Lt. Pike's observation. [illegible] mments certainly tends to make [illegible] at to say in the future.

[illegible] essential role in the progress of [illegible] e a debt of gratitude to the [illegible] years ago, had the foresight to [illegible] would bring the certainty of [illegible] of ventilation. We owe an equal [illegible], through research and inves[illegible] literature of ventilation engi[illegible] technical papers they have [illegible] men who, out of the wealth of their experience, have contributed to the Society through discussion, technical committees and GUIDE AND DATA BOOK activity. This spirit of cooperation and contribution has been, and continues to be, truly remarkable in ASHRAE.

In the late 1800's when the Society was being formed, ventilation practice was strongly influenced by the generally accepted rule that the whole purpose of ventilation was to prevent people from being poisoned by their own exhalations. In a somewhat arbitrary manner, carbon dioxide content was used as the principal indicator of the quality of air in ventilated spaces. The CO_2 concept led to a "magic number" of 30 cfm/person in occupied spaces. Many design procedures (and many state laws) were based on 30 cfm/person in spite of valid data which proved that CO_2 content was not the most important factor in the evaluation of vitiated air. Gradually as faith in the CO_2 myth was eroded away by the abrasive use of facts, a new culprit had to be found on which to blame the objectionable characteristic of poorly ventilated space.

One succeeding popular theory claimed that the objectionable characteristics of occupied spaces were caused by unidentified organic poisons excreted by human beings. These poisons were grimly identified as "morbific matter" or "organic effluvia." On the basis of scientific evidence, this theory was rejected by ventilating engineers but was not forgotten by others.

Modern TV pitchmen have used the implied horrors of the "human organic effluvia" theory to create a multi-million dollar market for scented soap, deodorants, special toothpaste and after-shave lotion. So much for scientific evidence.

During this entire period, engineers and doctors were working to establish a valid basis for human comfort by conducting extensive studies of various combinations of temperature and humidity. The study of humidity was an especially difficult and controversial subject. Significant results of this work were the Carrier Rational Psychrometric Formulae (1911), the Synthetic Air Chart accepted as a standard by the Society in 1920 and the ASH&VE Research Laboratory publication (1923), Effective Temperature Lines, which has been developed into the ASHRAE Comfort Chart.

The argument over air quality, which started prior to the formation of the Society, reached an emotional if not technical peak in 1926 after the New York State Commission on Ventilation published a report showing that schoolrooms ventilated by open windows were healthier for the occupants than schools ventilated by fan systems! This, of course, caused consternation in the Society. The New York State Commission study was founded on very questionable data and, in some cases, the data had been misinterpreted. However, the Commission's report had official standing and it took a major effort of the Society to combat its effects. It is to the credit of ASHRAE that this effort was made and that schoolroom ventilation standards were put on a valid engineering basis.

It may come as a surprise to present-day design engineers (and to present-day taxpayers) that today's public school construction "crisis" is not unique to our times. ASHRAE records from the early 1900's contain statements about the critical need for more public school construction that sound like statements quoted from this morning's paper. Much of the literature on ventilation during the latter part of the 19th century and up to the present time has been concerned with public school ventilation and considerable progress in ventilating techniques can be attributed directly to the continuous controversy over school ventilation.

The results of this progress now appear as the coldly impersonal formulas and design charts in ASHRAE GUIDE AND DATA BOOK which, rather unfortunately, do not reflect the controversial nature of their development. This controversy created an interesting emotional pitch at some Society meetings as indicated by the following comments made by a distinguished president of the Society at an annual ASHRAE meeting: "I think it is unnecessary to reply in any great detail to the last speaker because his is merely a rambling, erratic talk, clearly indicating that he knows nothing of serious knowledge about the subject of ventilation. I would say that he is more interested in the politics of the situation than in creating scientific methods of logical ventilation for the benefit of mankind." The statement may lack elegance but the meaning is certainly clear.

ASHRAE first gained official recognition from the U.S. government during World War I when a special committee was formed to study and make recommendations on the heating and ventilating of battleships and submarines. This was a major cooperative effort of many members and was given public recognition by the U.S. Navy.

Also during World War I, the Society took an active part in making recommendations concerning the adequate ventilation of barracks for the troops. The importance of army camp sanitation had been proven during the Spanish-American War when the mortality rate in camps reached frightening proportions. This may account for the wild enthusiasm to storm San Juan Hill—anything to get out of those camps!

In spite of this, at the outbreak of World War I, adequate barracks ventilation standards were not in existence and strong criticism was aimed at the heating and ventilating industry for this lack since there was a very real fear of the spread of communicable diseases in these crowded quarters. An ASHRAE committee was formed to study this problem and recommend standards.

Cooperation with the military branches of the government was again implemented during World War II. Members of the Society were active in all branches of the armed forces and the ASHRAE Research Laboratory in Cleveland was placed at the disposal of the government. Although a prodigious amount of work was done by ASHRAE members, very little appears in ASHRAE publications because most of the work ended up in the oblivion of classified military reports.

In addition to its impressive record in the field of ventilation standards, the Society has a long and distinguished history of research and development work on the subject of fluid flow in ducts, duct fittings, inlets, outlets, transitions and plenums.

ASHRAE GUIDE AND DATA BOOK has become the accepted standard for data of this type. Some remarkable contributions have been made in the study of flow in air jets and the distribution of air in rooms when various methods of introducing the air are used. Much of the work was done at the Society's own former Research Laboratories in Pittsburgh and Cleveland under the direction of technical committees. In addition, research has also been conducted and, in some cases, is being continued at colleges and universities throughout the country. Institutions associated with ventilation studies are Case, Illinois, Kansas State, Minnesota, Wisconsin, Texas A & M, Michigan State, and Texas. Recent developments in this area have been mainly concerned with high velocity flow in air ducts and it is quite likely that this activity will continue as the problems of available space for building services become more acute.

Exhaust system design has always been a special problem in connection with industrial ventilation and, here again, significant contributions were made by Society members. Exhaustive studies were made of the nature of airflow at suction openings and exhaust hoods. The results have not only served as the basis for design procedures but have also been used as industrial standards and as state and federal regulations.

Mine ventilation has always attracted wide interest but early mine ventilation suffered from lack of valid engineering information. Explosions and fires in mines were all too common both here and abroad and while ventilation was recognized as part of the solution, the proper methods were not fully understood. Some mines were ventilated by building fires in the base of a deep vertical shaft and using the chimney action of this shaft to ventilate the mine. When explosive mine gases came in contact with the fire, the results were spectacular.

The obvious need for more dependable methods of mine ventilation was directly responsible for much of the early development of industrial fans. The need for moving large quantities of air resulted in the construction of very large fans and the resulting horsepower requirements created a demand for more efficient designs. For sheer size, some of the early mine fans have not been equalled since. The change from slow speed steam engine drives to electric motor drives resulted in the development of smaller-diameter, high-speed rotors. Any scientific development worth the name must be able to trace its origin back to the ubiquitous Leonardo da Vinci and fan design qualifies since a sketch has been found in Leonardo's notebooks of a water powered fan. Considering only more recent history, fan design during the life of the Society has progressed from simple radial steel plate centrifugal fans to the modern high-efficiency airfoil fans. Simple wall type propeller fans were the fore-runners of today's highly developed axial flow fans. The National Assn of Fan Manufacturers (NAFM) Fan Test Code was first accepted as a standard by the Society in 1923.

Vehicular tunnel ventilation was studied at great length due to the increased use of internal combustion engines. When the Holland Tunnel was in the design stages, elaborate models were made of the ventilating system and extensive tests were conducted to determine the optimum design for proper ventilation. The results of these studies became standard reference material for many subsequent tunnels.

As mentioned earlier in this article, progress in ventilation has been due to the combined efforts and cooperation of many, many ASHRAE members. ASHRAE has, furthermore, made much of this progress possible not only by sponsoring Society research projects but also by providing a means for the exchange of information throughout the industry. The development of ventilation engineering has always been an integral part of ASHRAE activities and it is quite obvious that this will continue to be a major part of future ASHRAE programs.

A HISTORY OF HEATING

JOHN W. JAMES
Presidential Member ASHRAE

BY the time our Society was founded in 1894, the concept of central heating was fairly well developed, and the basic heat source took the form of either a warm air furnace or boiler.

However, the most primitive method of heating was the open fire, and the first notable step in the evolution of the heating system consisted of the addition of a chimney

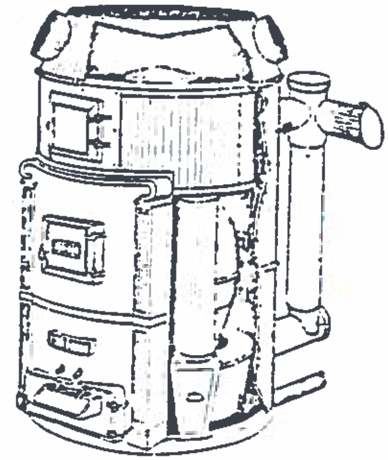

Fig. 1 Gravity warm air furnace

to carry away the products of combustion, from which it was but a short step to the fireplace and then to the stove. Actually, some of the early furnaces enclosed a conventional heating stove in a shell composed of two metal casings with an insulating air space between the casings, similar to the arrangement shown in Fig. 1. The air circulated through the space between the combustion chamber and the casing, absorbing heat from the hot surfaces of the fire pot and gas passages. Some of the higher capacity furnaces used in the larger residences, and in the smaller schools were set in a casing of brick.

The early warm air furnace combustion chambers were constructed of cast iron, but in recent years the welded steel furnace has become rather widely used. The force producing circulation in a gravity warm air furnace system is due to the difference in density of the air in various parts of the system. As this force is extremely small, the design of the entire system must allow for the air to circulate freely in spite of the small motive force.

The outer furnace casing was arranged with conical hood or bonnet (Fig. 2), from which the leaders or warm air round pipes radiated at the same pitch with connections to either the first floor registers or second floor stacks. Return air ducts were an important part of the air circuit and connections from as many rooms as practicable were recommended. Because the leader pipes and return ducts were designed to be as short and direct as possible, it was generally agreed that a gravity furnace should be located in a central position.

The next important innovation in the development of the furnace system was the addition of a fan to provide a mechanical means of forcing air through the duct system.

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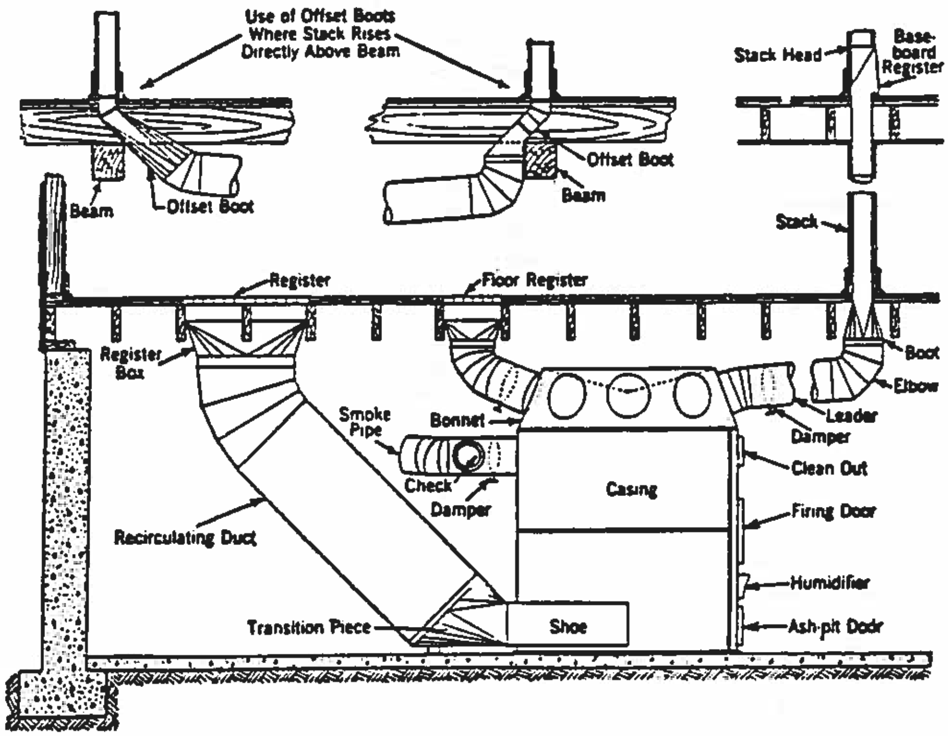

Fig. 2 Gravity furnace distribution piping

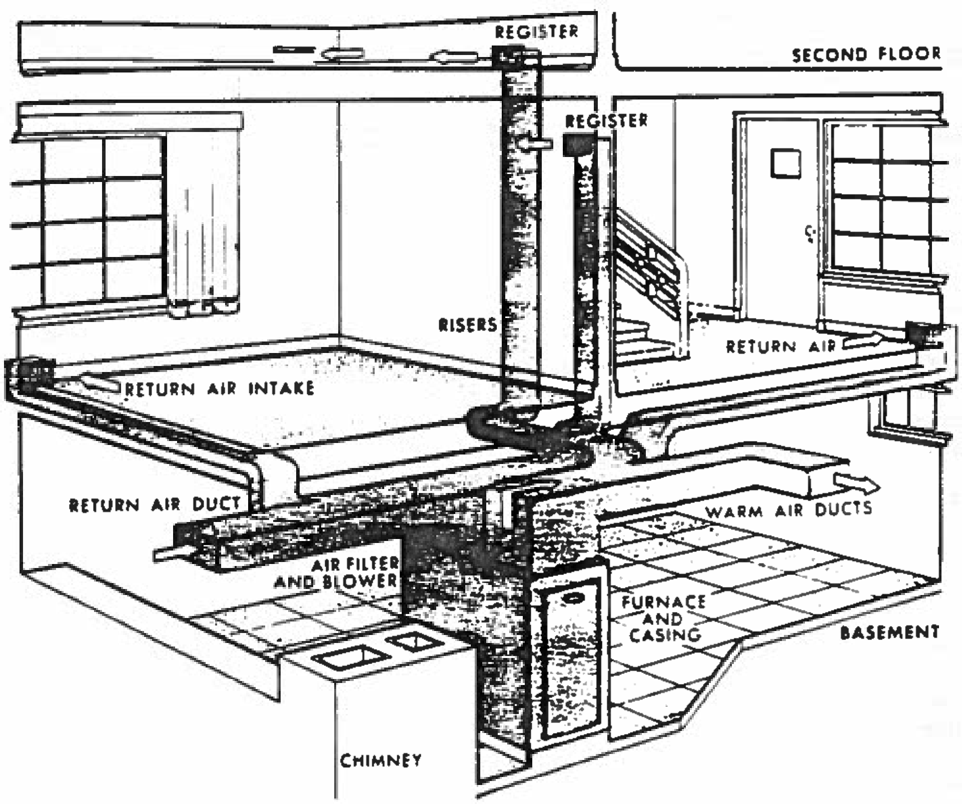

Fig. 3 Forced air furnace distribution piping

Whereas it might be assumed that this development was of recent origin, there are references in the 1899 ASH&VE TRANSACTIONS[1] to an "electric fan" and the use of "four-inch hot-air pipes."

Some of the first conversions of gravity to forced warm air furnace systems involved the addition of a packaged unit, comprising a motor-driven fan and air filter assembly, which could be installed adjacent to the furnace. Later developments combined all of the basic components in an assembly with duct-distribution arrangement (Fig. 3).

Modern concepts of the furnace system are now realized in miniaturized design creations which permit exceptional versatility with regard to location. Slender, vertical or horizontal, upflow or downflow furnaces may be located in closets, crawl spaces, attics, or garages, as well as in the basement. Of course, cooling has been added to these systems, together with humidification apparatus, improved air distributors, and means for removing air impurities. The developments which perhaps overshadow all others in the furnace field were the gradual conversions of furnaces from coal to oil and gas, and from manual to automatic firing.

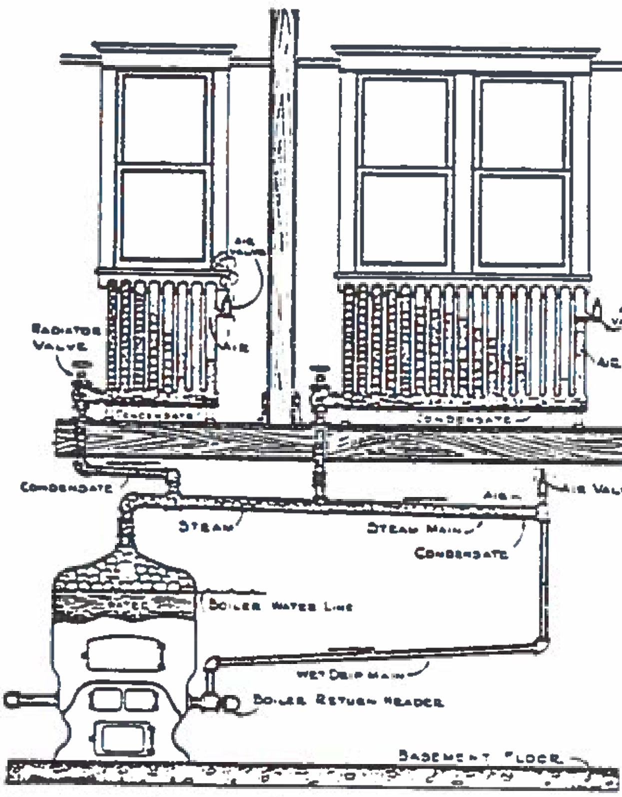

Fig. 4 One-pipe steam heating system

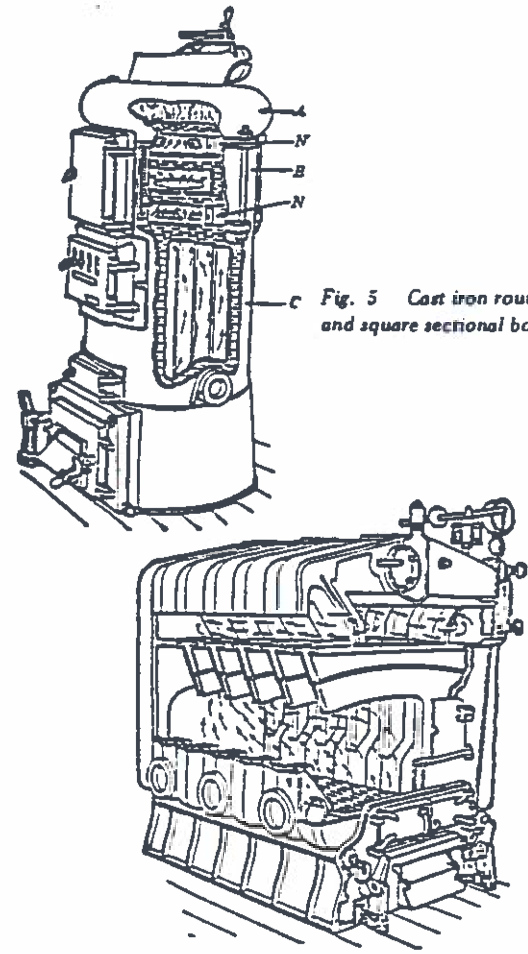

Fig. 5 Cast iron round and square sectional boilers

The first 10 volumes of ASH&VE TRANSACTIONS record that a majority of the discussions dealt with the design and operation of steam heating systems. True, James Watt is generally credited with developing the first steam heating system around 1770, but it was not until the early 1900's that the first real breakthrough occurred for improving the circulation problems in steam systems with the introduction of a fluid-operated thermostatic trap.

Prior to this date, the one-pipe steam heating system (Fig. 4) was the system in general use. Steam was supplied either from boilers or engines as indicated in Fig. 4. When ASHRAE was founded in 1894, cast iron and steel were commonly employed for heating boiler construction. Cast iron boilers were available in either fire-tube or water-tube design, and were always constructed of sections joined together by some form of nipple or header connection. Cast iron boilers of the fire-tube type were available in either round or square section design (Fig. 5).

Some of the very early cast iron boilers were arranged with enclosing brick chambers. In addition to feeding steam to radiators in more distant locations, steam was also fed to indirect pin type radiators located in the same chamber as the boiler, which permitted warming air to be conducted to the rooms. A similar arrangement for warming air with a radiator and separate duct system is diagrammed in Fig. 6.

Heating boilers constructed of steel were generally available in several categories, which may be summarized as brick set, portable firebox, fire-tube, water-tube, down-draft, up-draft, single-pass and multiple-pass for the flue gases, and vertical and horizontal types.

Until fusion welding of steel boilers became generally accepted, it was common practice to rivet horizontal return-tubular fire-tube boilers (one of which is shown in a brick set arrangement in Fig. 7).

About the same time that the water-tube type cast iron sectional boilers were being developed, a steel type water-tube boiler was being perfected, which was later redesigned to resemble the sectional drawing shown in Fig. 8.

The dry-back Scotch boiler is the early forerunner of the modern all-welded steel type package boiler-burner unit that is available in multiple-pass flue gas travel arrangement and of dry- or wet-back construction. Many of these boilers are factory-assembled with automatic controls and accessories, which permit delivery to site complete – ready to fire with merely connections to fuel, power and flue.

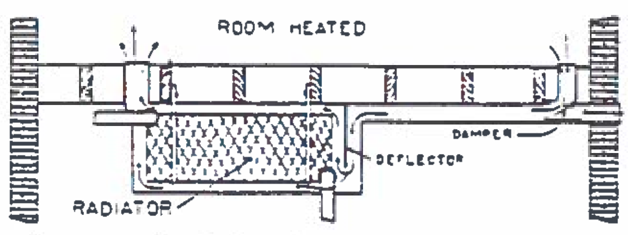

Fig. 6 Warming air with radiator

During the period from 1900 to 1925, the use of two-pipe steam systems with thermostatic traps at the outlet of each radiator and at drip points in the piping became widely accepted. In the smaller buildings, gravity systems for return of condensate were commonly installed. For the larger systems, boiler return traps and condensate pumps with receivers were used to return condensate to the boiler. By 1926 the vacuum return line system was fully perfected for installation in large and moderate size buildings.

Hot water heating systems paralleled the development of steam systems, first with gravity systems, which depend on the difference in density of hot water in the pipes leading to the radiators and the cooler water returning from the radiators for system circulation. In 1927, a circulator was introduced in a two-pipe arrangement for forcing water through the system. The later development of a diverting tee which permitted forced circulation in a one-pipe system has had wide acceptance.

At the turn of the century, a bar-type cast iron radiator

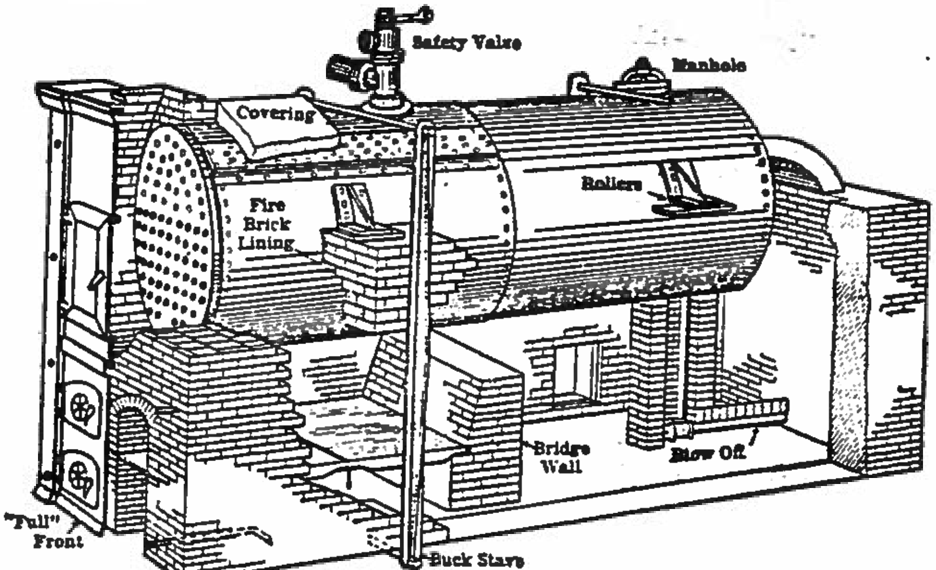

Fig. 7 Horizontal return tubular steel boiler

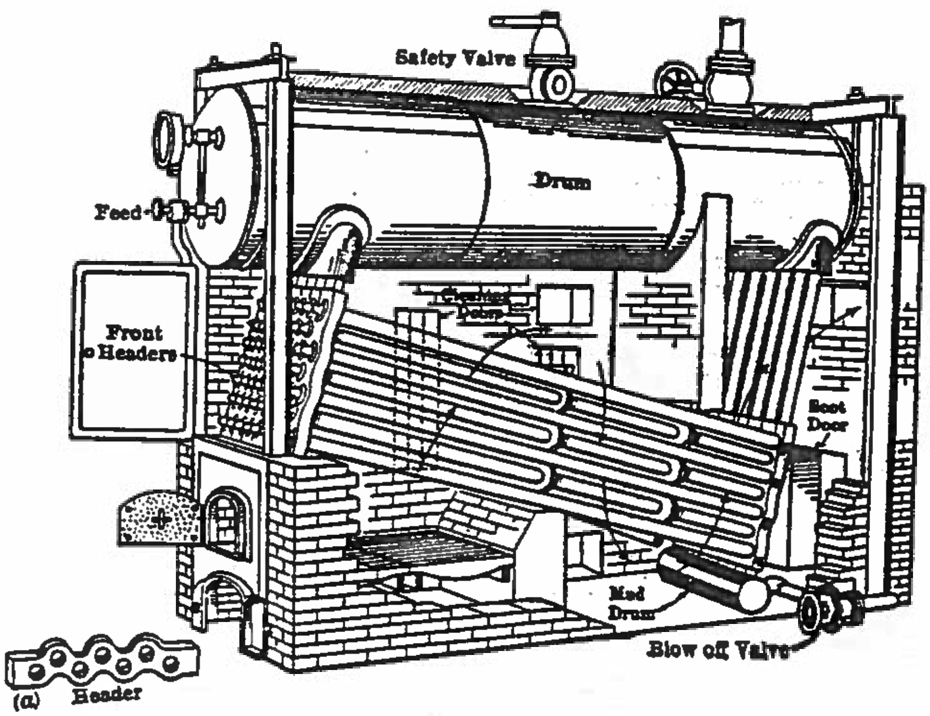

Fig. 8 Water-tube steel boiler

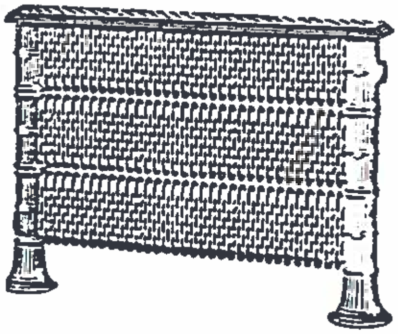

Fig. 9 Bar-type cast iron radiator

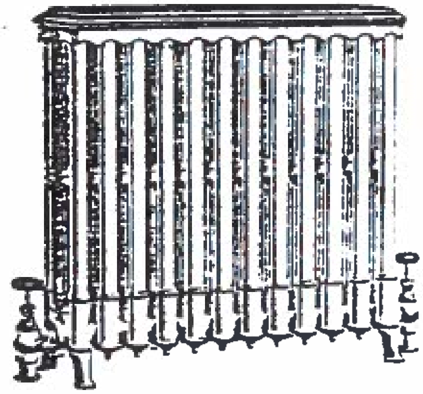

Fig. 10 Sectional cast iron radiator

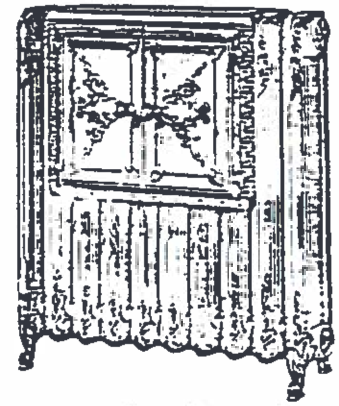

Fig. 11 Cast iron radiator with warming oven

was manufactured (Fig. 9). A later radiator development consisted of sections joined to each other at top and bottom, with the end sections acting as supports as illustrated in Fig. 10. Radiator designs became quite elaborate with one arrangement incorporating a warming oven for use in dining rooms (Fig. 11)

In the 1930's there was a trend towards concealment of radiators and convectors using enclosures, shields and cabinets. One form of concealment involved furring the convector in the wall as diagrammed in Fig. 12. About 1944, the baseboard radiator was developed in both ferrous and non-ferrous designs, with the latter depicted in a typical installation in Fig. 13. Baseboard heating has contributed to the reduction in floor-to-ceiling temperature stratification, thus greatly improving comfort conditions.

Two other forms of convection heating equipment which were developed in the early 1920's for commercial and industrial applications may be referred to as unit heaters and unit ventilators. Unit heaters were made available in both suspended and floor types, and could be classified according to use of heating medium, such as: steam, hot water, electricity, or the products of combustion of gas, oil or coal burned within them. Unit ventilators were first introduced for use in school buildings, and were often equipped with an air filter in addition to the heating element and fan. Many designs incorporated provisions for air recirculation, and a separate outdoor air connection.

Panel heating is another type of heat distribution which has historical significance. Widely used in England and other parts of Europe, it was not introduced in this country until around 1928 when the first installation was made in the British Embassy building in Washington, D.C. Panel heating may be described as a system arrangement whereby the fluid, whether it be hot water, steam, air or electricity, is circulated through distribution units embedded in the building construction.

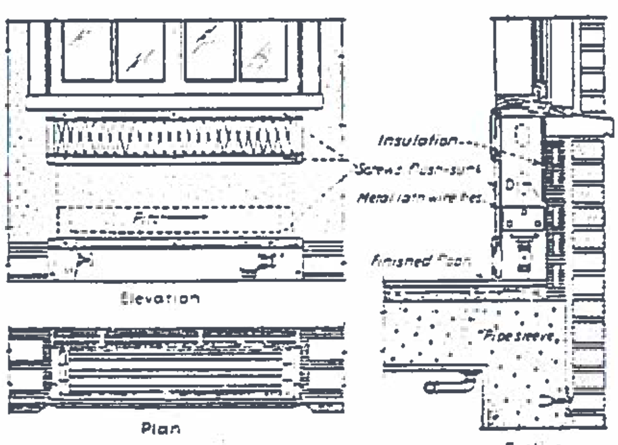

Fig. 12 Concealed non-ferrous convector

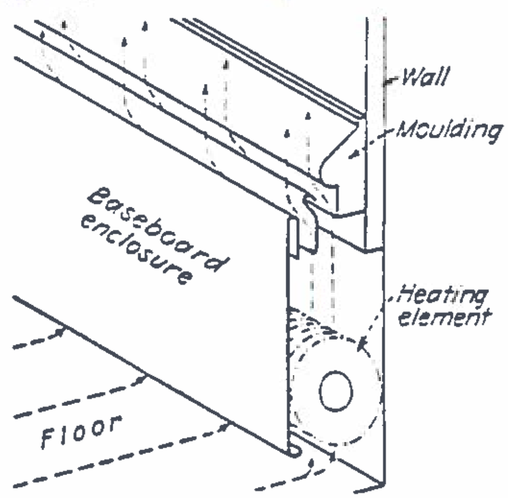

Fig. 13 Baseboard radiator

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History of
ASHRAE GUIDE AND DATA BOOK

CARL H. FLINK
Fellow ASHRAE

THE ASHRAE GUIDE AND DATA BOOK is a combination of the ASHAE HEATING VENTILATING AIR CONDITIONING GUIDE and the ASRE DATA BOOK. Most important factors in bringing the two societies and their books together in a merger were the development and growth of air conditioning. While heating and ventilating were the primary interests of ASH&VE, when founded, and refrigeration for preservation of food was the main interest of ASRE, the members of both societies became increasingly concerned with air-conditioning applications as time went on. Both groups used similar tables of properties of air and moisture, similar tables of heat transfer through materials, and the same type of equipment for producing desired environmental conditions – whether for comfort, manufacturing, or preserving food or materials.

Both societies from time of founding looked upon the production and publication of the best available design data as a main objective for existence. As a main source of reference for design information the ASH&VE (changed to ASHAE because of the importance of air conditioning) published the HEATING VENTILATING GUIDE or the HEATING VENTILATING AIR CONDITIONING GUIDE annually from 1922 through 1960. ASRE published its DATA BOOK at established intervals from 1932 to 1959, the last volume being the AIR CONDITIONING REFRIGERATING DATA BOOK, 1959 (Refrigeration Applications).

Following the merger of ASHAE and ASRE into one society, it was decided to consolidate THE GUIDE and the DATA BOOK into a series of books under the title ASHRAE GUIDE AND DATA BOOK and to use as many books as necessary to permit the grouping of related subjects in the most convenient arrangement for the user.

The general committee appointed to take charge of the consolidation was called the Guide And Data Book Committee. This committee was expected to operate through subcommittees, one for each book to be prepared.

The procedure for obtaining data for each book was the same as for past books – information from any authoritative source acceptable to the committee was considered suitable. Heavy reliance for obtaining data and preparing text was placed upon society Technical Committees and Task Groups, as well as upon individuals who could contribute design data from their practice or research. Society-sponsored research was a source of much information.

The great accomplishments of the Guide And Data Book Committee and its subcommittees from 1961 to 1969 are evident from the completed books listed below (numbers 1 to 10). In each of the books, individuals who have been particularly active in preparation of material are listed in the preface pages. Their industry affiliations and the chapters in which they have been involved are indicated in appreciation of their valuable contributions.

1. ASHRAE GUIDE AND DATA BOOK 1961. Fundamentals and Equipment
2. ASHRAE GUIDE AND DATA BOOK 1962. Applications
3. ASHRAE GUIDE AND DATA BOOK 1963. Fundamentals and Equipment (a revision of 1961 volume)
4. ASHRAE GUIDE AND DATA BOOK 1964. Applications (a revision of 1962 volume of same title)
5. ASHRAE GUIDE AND DATA BOOK 1965-66. Fundamentals and Equipment (a revision of 1963 volume of same title)
6. ASHRAE GUIDE AND DATA BOOK 1966-67. Applications, (a revision of 1964 volume of same title)
7. ASHRAE GUIDE AND DATA BOOK 1967. Systems and Equipment (a new arrangement replacing former Fundamentals and Equipment volume 1965-66)

   This book presents for the first time information on equipment used in heating, refrigerating, air conditioning and ventilating, plus design data for systems based on combinations of equipment. Included are data on equipment available in the field, how the equipment functions, factors to look for in selecting such equipment, how each component affects other equipment, and how to combine equipment with other components to form complete systems.
8. ASHRAE HANDBOOK OF FUNDAMENTALS 1967

   A book of fundamental theory and basic data pertaining to heating, refrigeration, air conditioning, and ventilation, for use as a basic text for the student or newcomer to the industry and as a basic reference for the experienced engineer. Applicable fundamental data from the 1965-66 volume were used where suitable. New charts, tables, and data from various other sources were added. This book is scheduled for a 4 to 6 year cycle of revision.
9. ASHRAE GUIDE AND DATA BOOK 1968. Applications (a revision of the 1964 volume of same title)
10. ASHRAE GUIDE AND DATA BOOK 1969. Equipment (first volume with this title – revision scheduled for 1972)

C.H. Flink was Technical Secretary of ASH&VE (later ASHAE), 1944-1960, Editor of HEATING VENTILATING AIR CONDITIONING GUIDE, *1944-1960, and Editor of* ASHRAE GUIDE AND DATA BOOK, *1961-62. Mr. Flink died in December 1969, shortly after this article was written.*

In addition to these 10 books, the Guide And Data Book Committee is preparing the following two books (numbers 11 and 12).

11. ASHRAE GUIDE AND DATA BOOK 1970. Systems (first volume with this title – revision scheduled in 1973)
12. ASHRAE GUIDE AND DATA BOOK 1971. Applications (a revision of 1968 volume of same title – revision scheduled in 1974)

When these two books (numbers 11 and 12) are published, the consolidation of the ASHAE GUIDE with the ASRE DATA BOOK will have been completed. The complete final series of these books will then be:

ASHRAE HANDBOOK OF FUNDAMENTALS 1967 (next revision 1972)

ASHRAE GUIDE AND DATA BOOK – Equipment 1969 (next revision 1972)

ASHRAE GUIDE AND DATA BOOK – Systems 1970 (next revision 1973)

ASHRAE GUIDE AND DATA BOOK – Applications 1971 (next revision 1974)

Since the ASHAE GUIDE and the ASRE DATA BOOK were very successful projects of the two societies and since they served to establish a firm foundation upon which to build ASHRAE GUIDE AND DATA BOOK, it will be interesting to society members to have a brief record of the origin and development of both books.

THE GUIDE – 1922 to 1960

According to earliest records, it was Perry West, consulting engineer and chairman of the ASH&VE Publication Committee, who proposed in 1921 that the society publish annually a reference book covering design and construction in the field of heating and ventilation.

This book was proposed as a service, not only to the members of the society, but also to the heating and ventilating industries. Its purpose was to provide the engineer, architect, and contractor alike, with a useful and reliable reference data book relating to the art of heating and ventilating.

A special feature of the book was that information was to be presented in a practical and readily usable form so that the busy engineer, architect, contractor, or others would be spared laborious deductions from miscellaneous data, or the making of lengthy studies of a mass of superfluous matter. In other words, the text was to be direct, simple, and easily understood for application to design work.

It was also proposed that the book contain a section in which manufacturers could list and illustrate products which the designer could use when making layouts of systems. It was suggested that products shown should be accompanied by tables of dimensions, ratings, capacities, and other factors to facilitate proper selection. A Manufacturers' Catalog Data Section was, therefore, recommended for the convenience and benefit of both designers and manufacturers.

It was also considered probable that revenue from sales of advertising space plus sales of books would result in an accrual of funds that could be used to increase the services of the society.

The proposal of the ASH&VE Publication Committee when submitted to the Executive Committee and Council was approved on October 21, 1921. The Council appointed a special committee, the Guide Publication Committee, to which it gave the responsibility for preparing and publishing the first edition without cost to the society. Members of the committee were: Perry West, Chairman; Homer Addams, Treasurer; J.E. Bolling, Secretary; S.E. Dibble; W.H. Driscoll; E.S. Hallett; J.I. Lyle; and C.L. Riley.

The Council also specified that if there were funds accruing to the society from the publication, such funds should be devoted to society research. There was agreement that the first edition should be ready for distribution as promptly as possible after the 1922 Annual Meeting and consequently the committee was instructed to meet this publication time.

The official title adopted for the book was: AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS GUIDE (with year of publication added). The contraction of the title to THE GUIDE was not established by society action but gained acceptance almost immediately and appears seven times in the preface of the first edition (1922).

It is of interest that the first edition, 7000 copies, was available for distribution in February 1922. The increase in demand for THE GUIDE in each succeeding edition made it necessary to print 30,000 copies in 1960.

Annual succeeding editions of THE GUIDE up to 1960 were prepared under continuing Guide Committees augmented and changed according to the demand for treatment of new subjects or improvement of preceding material. A review of the index of chapter subjects treated in any edition reveals the society's growth of interest and concern with all latest developments at the time. Thousands of leading engineers and scientists have contributed data and maintained supervision of text ever since THE GUIDE was first published and have thereby established the authoritative position of the book.

Due to the rapid accumulation of technical data from society and other research and from new developments in heating, refrigerating, and air-conditioning practice, various means were used to provide more space for technical data in succeeding editions of THE GUIDE. Such means were: increase of the amount of type per page, reduction of type size where practicable, reduction in paper thickness, and finally a change from 6 by 9 to 8 1/2 by 11 in. page size which became effective in the 1959 edition.

ASRE REFRIGERATING DATA BOOKS – 1932-1959

In 1932 ASRE published the first volume of a series of reference books that were planned to make available to refrigerating engineers and the public all known information on refrigerating processes.

The publication of the first edition was authorized by the ASRE Council in May 1931 after the project had been started and carried well along under the active leadership of Alvin H. Baer, ASRE President – 1931, and Glenn Muffly, President – 1932. The project had been suggested by David L. Fiske, Executive Secretary of ASRE.

The following members were chiefly responsible for preparation of the first edition:

Data Book Committee: Alvin H. Baer, Jesse B. Churchill, Harry D. Edwards, Crosby Field, Glenn Muffly, Alfred W. Oakley, H.M. Williams, Frank R. Zumbro, and David L. Fiske, editor.

Advisory Board: A.J. Authenrieth, Charles W. Berry, George B. Bright, Willis H. Carrier, F.L. Fairbanks, George A. Horne, L. Howard Jenks, H.J. Macintire, Harry Sloan, A.R. Stevenson, Jr., R.H. Tait, E.T. Williams, and W.R. Woolrich.

Authors (of chapters): E.S.H. Baars, Clarence Birdseye, John T. Bowen, R.H. Brown, B.H. Coffey, R.C. Doremus, C.O. Dueval, Harry D. Edwards, W.H. Eldridge, W.L. Fleisher, John Everetts, Jr., R.T. Frazier, V. de P. Gerbereux, M.N. Halberg, George A. Horne, George E. Hulse, George Lange, H.J. Macintire, V.L. Maleev, J.W. Martin, D.W. McLenegan, Alfred W. Oakley, Maurice Olchoff, Fred Ophuls, L.C. Roberts, F.H. Stiening, F.C. Stewart, W.R. Woolrich, Frank R. Zumbro.

For preparation of subsequent editions, including the 1959 (last) edition it was customary to appoint an editor-in-chief under whom there were associate editors for sections as well as an editor, or author for each chapter.

Table I, which shows the year of publication and the title of each ASRE DATA BOOK, illustrates that *air conditioning* shares equal prominence with *refrigerating* in the titles of the 1953 through 1959 editions. Actually, air conditioning was also treated in several chapters of the 1940 edition in which there appears a statement that "this book presents all known applications of air conditioning and refrigeration."

Table I. ASRE DATA BOOKS

Year of publication	Title
1932-33	Refrigerating Data Book and Catalog
1934-36	Refrigerating Data Book and Catalog
1937-38	Refrigerating Data Book and Catalog
1939-40	Refrigerating Data Book and Catalog (Vol. I, Refrigerating Principles and Machinery)
1940	Refrigerating Data Book and Catalog (Vol. II, Refrigeration Applications)
1942	Refrigerating Data Book and Catalog
1946	Refrigerating Data Book and Catalog (Vol. II, Refrigeration Applications)
1949	Refrigerating Data Book and Catalog (Basic Volume)
1950	Refrigerating Data Book and Catalog (Applications)
1951	Refrigerating Data Book and Catalog (Basic Volume)
1952	Refrigerating Data Book and Catalog (Applications)
1953-54	Air Conditioning Refrigerating Data Book (Design)
1954-55	Air Conditioning Refrigerating Data Book (Applications)
1955-56	Air Conditioning Refrigerating Data Book (Design)
1956-57	Air Conditioning Refrigerating Data Book (Applications)
1957-58	Air Conditioning Refrigerating Data Book (Design)
1959	Air Conditioning Refrigerating Data Book (Refrigeration Applications)

In preparing the ASRE REFRIGERATING DATA BOOKS, it was the editorial policy to include all fundamental data on the art of refrigeration as well as all practical application data possible. The object was to make the book a valuable reference for both the novice and the experienced engineer. In the 1934 edition, for instance, the 470 pages of technical text included 30 chapters which described theory, means of refrigeration, and machinery used in refrigeration applications. Several chapters dealt with air conditioning, in theory and practice.

In 1940, the DATA BOOK was entirely different from any previous edition. It consisted wholly of practical how-it-is-done chapters on all known applications of refrigeration.

While the first three editions of the REFRIGERATING DATA BOOK were single volumes, the rapid accumulation of technical data on all refrigerating subjects, as well as on air conditioning, made it necessary to add more book space. Consequently, it was necessary to arrange the new material among the different editions as evident from Table I.

In considering the authoritative standing of the ASRE REFRIGERATING DATA BOOK, it is obvious that the high quality of its information was due to the continuing interest and vigorous participation of the outstanding leaders in the refrigeration field. Most of these leaders were society members.

CONCLUSION

Upon reviewing the past activities of ASH&VE, ASHAE, ASRE, and ASHRAE it is evident that publication of ASHRAE GUIDE AND DATA BOOK is one of the most valuable accomplishments of these societies.

THE HUMAN HABITAT-1994

WILLIAM L. McGRATH
Presidential Member ASHRAE

THE Human Habitat – 1994. This is an awesome title and I must confess that I became committed to the title before I prepared this address and this froze me into the role of prophet which is a precarious avocation at best. After studying a number of case histories in the area of forecasting economic or technological trends and developments, I have come to the conclusion that the way to play the role safely is to be bold about it and make your projections far enough into the future so that when that time comes, no one will remember what you forecast anyway. What a prophet must avoid is predicting what will happen, say, six months out, for people then will remember and the prophet will be without honor not only at home, but abroad as well. Thus, my intention of making a prognosis relating to man's environment and its relation to our industries 25 years out should be completely safe.

One of the important techniques used in making economic and technological predictions is the process of statistical projection, which is really the extrapolation of the experiences of the past to draw a prognosis for the future. By this means, one can arrive at really astounding conclusions. For example, if we make a 25-year plot of the percentage of the population enjoying welfare or social security payments, and extrapolate these data for the future, we find that by the year 1994 apparently no one will be working. This will make for a very interesting economy.

On the other hand, if we examine the history of the annual wage of a typical construction trade, plumbing, for example, we find an impressively high rate of growth, and if we extrapolate into the future, we find that by 1994 the average plumber will be earning nearly $50,000 per year. Somehow this seems at variance with the conclusion reached in the preceding example.

Forecasting from trend curves is a really fascinating pastime. It has been pointed out that a conclusion one might reach by extrapolating the speed-time trend curve is that manned spacecraft will achieve the speed of light by 1994. If we can believe Einstein, the astronauts of that day are going to have an overweight problem of some magnitude. Also, if you extrapolate the life-expectancy-at-birth curves, it would appear that everyone is going to be immortal after the year 1994.

One way to acquire perspective about forward-looking projections is to remember how things looked to us 25 years ago in relation to what has actually transpired in the intervening 25 years.

Looking back to 1944, which really doesn't seem very long ago to some of us, this was the year that the Normandy invasion was launched and Paris was liberated, while B-29's were bombing Tokyo with conventional bombs. And that was the year that the United Nations was formed. The population was 139 million, the federal debt was just over $200 billion, and the gross national product was $210 billion. The average weekly earnings in the manufacturing industry were $45.85, while the work week averaged 45.1 hours – just about a dollar an hour.

That was the year, too, of the Cleveland disaster, an explosion of a liquefied gas tank causing many fatalities. This unfortunately inhibited the more rapid development of the technology of liquefied natural gas, a deficiency which now, of course, is being well rectified. Railroads still tolerated people and were traveled on except for those intrepid few who took to the air and might make 200 mph

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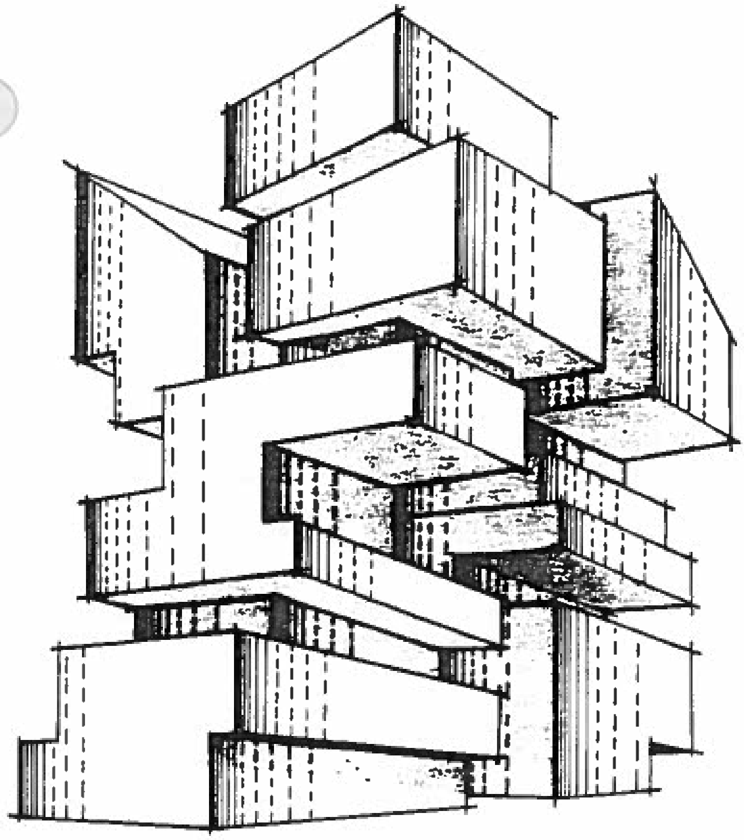

in a propeller plane. Comparing this to the 25,000 mph that our Lunar Astronauts travel gives one a measure of the kind of change that can occur in 25 years. In 1944, as far as the general public was concerned, the concept of tapping nuclear energy for any purpose was unknown and unheard of. Yet, 25 years later it looms in our lives as the most awesome potential for good or evil that mankind has ever contemplated. In that span of 25 years, one can see other less startling but still significant developments that are fair indicators of what could happen in the next 25. Electric energy production went from 280 to 1550 billion kwh – a 5 1/2-fold increase. Disposable income went from $146 billion to $630 billion representing an increase of 330% on a per capita basis. In constant dollars, the per capita increase was 50%. There were less than 700,000 tons of air conditioning installed and operating in 1944. That figure today is nearly 70,000,000 tons, a 100-fold increase. Annual sales of air conditioning for buildings went from an (estimated) 80,000 tons in '44 to 13,600,000 tons in 1969.

Actually, while I can cite many examples of inept forecasts of coming events, other forward-looking projections of the future have proved remarkably accurate. For example, Jules Verne in 1865 described in the most extraordinary detail the equipment needed for a lunar space flight – the required trajectories, release speeds and the key factors governing a journey that did not take place until 1969, 104 years later.

Closer to home, Willis Carrier in 1940 predicted in a Sunday newspaper article two developments that have indeed come to pass. One of these was the proposal for central plant facilities delivering chilled or heated water to whole city areas. The other prediction was that of enclosed and air-conditioned shopping malls and pedestrian walkways, now rather common.

One might ask, relating to the air-conditioning industry, of what value is this business of trying to forecast the future? Why should we try to visualize conditions 25 years from now? Is it simply because that will be the next quarter centennial celebration of ASHRAE?

I think not. It seems certain that any industry that does not try to see the pattern of the future 20 to 25 years away is doomed. It did not take 25 years to put the buggy whip makers out of business, and the aircraft industry was turned upside down by the advent of the jet engine in less than 10 years.

Even in the air-conditioning industry, we find that the effective commercial harvest from research activity can well be 10 to 15 years beyond the point where the activity is initiated. Recognizing this, it also follows that you cannot really look 15 years ahead with any effectiveness unless you try to project conditions beyond that. Thus, a 25-year visualization of the world to come gives a better clue as to the kind of decisions necessary in the next 10 or 15 years.

Of special significance to our future is the population trend projection. In the next 15 years, the United States will go from 200 million to 255 million people and, by 1994, it is predicted that our domestic population will be between 300 and 350 million. The world population by that year may have doubled and the seven billion people then living in the world would need four times today's food production.

People are going to flock to the cities. For example, by the year 1985 it is predicted that the San Francisco Bay area will have grown from 5 million today to nearly 10 million people. The Los Angeles area may go from 8 million to 15 million in the same period, and the Washington/Baltimore area from 4 million to 8 million. Many other urban centers have a similar future in store.

These population trends and the rapid urbanization of the nation indicate that we will soon run out of land for the building of single-family homes. Already, in some communities the urban sprawl is so extensive that it is beyond the capability of transportation methods to provide a suitable ecology for the community. Yet, in spite of this, it can be predicted that the population of many such areas will more than *double* in the next 15 to 25 years. Higher density housing seems to be *the only conclusion*. This is not to say that single-family homes will not continue to be built, but the great bulk of housing must necessarily be of relatively high density.

There is no longer any disagreement along political lines concerning the desperate need to do away with slums and ghettos. Two presidents have stated that the nation will have to construct 26 1/2 million additional housing units in the next 10 years. From the report, Building the American City, by the National Commission on Urban Problems, this comment is taken:

> "It is significant that we use the word 'jungle' in talking about our cities. For this scene, this setting for city life is not an urban setting for urbane citizens. The city has become a crude and ugly place and those who can do so flee to the suburban countryside, to houses set in the green valleys and along the forested hills. The city has become the place where the poor and the discouraged cling together in neglected houses along dreary streets.
>
> "Without saying too much about it, most families have come to believe that the city is not a decent place to bring up children. Few talk about *making* city life *good* for children."

More recently the Presidential Commission on Crime has publicized conclusions that are startling. The rate of violent "crime in the streets" of the United States is 15 to 20 times as great as in other "civilized" nations such as England and other European and Scandinavian countries. The cause and cure, according to this Commission, is to be found in the urban environment.

I think we must conclude that the housing needs of the future cannot be met by building instant slums. If we do not create housing and an urban environment that is of decent quality, we are going to add to our woes through the necessity of doing the whole job over again.

We may ask just what all this has to do with the future of the air-conditioning industry, the future of our technology, and the challenges facing our engineers.

Concerning this most important task of the '70's and '80's, the following premises may be postulated and directly related to us and to the air-conditioning industry:

1. The conclusion must be reached that the major portion of the needed new housing in the next 15 or 25 years must be of a high density nature, not detached, single-family dwellings.
2. Complete environmental control (air conditioning) in such dwellings should permit architectural design that will have a lower overall first cost of construction.
3. Complete environmental control can provide a lower monthly living cost than non-controlled habitations.
4. Complete environmental control will provide desirable and even necessary sociological benefits.
5. Complete environmental control may open the way for really innovative architectural design which will be pleasing and convenient and provide a degree of satisfaction in family living not otherwise available at the required higher density of population.
6. The methods of the manufacturing community involving inspired product development, cost and value conscious design, sophisticated tooling and machinery and efficient fabrication and assembly methods must be employed to get the job done.

I believe it can be demonstrated that the use of complete air conditioning will offer design concepts to the architect which can permit a lower cost building than can otherwise be obtained. This is true because without summer air conditioning, dwelling units must be designed to alleviate hot weather suffering by means of natural ventilation which, in turn, leads to the need for many windows, cross ventilation, and therefore a relatively large amount of outside wall per dwelling unit. The outside wall of a building, with its costly facing, insulation, fenestration, hardware, is every expensive. Therefore, if we can reduce the ratio of outside-wall-to-floor area, we should obtain progressively lower costs. In terms of a typical dwelling unit, one could consider a practice where the outside wall might be only 10 to 20% of the area of the floor.

Those suburban dwellers who may react unfavorably to the premise that we must relieve a heat stress problem in high density housing should remember that the night-time temperatures in suburbia will be 12, 15 or even 20 F lower than maximum daytime temperatures. However, in crowded urban areas there is no corresponding relief because of the substantial inertia of masses of concrete, stone and brick, as well as the absence of sources of moisture, such as water-laden vegetation. Air pollution may further increase city temperatures by retarding the escape of generated heat.

Of even more importance than construction costs is the monthly living cost of the dwelling unit. Considering all the aspects of the financing and tax structure which will probably apply to these projects, the first cost can become less a consideration than the operating cost of the structure. Thus, structures employing a low outer-wall-to-floor ratio will benefit substantially through reduced heating loads and reduced cooling loads, with a "heating with light" potential and corresponding heat conservation possibilities. Such costs as window-washing, painting, pointing and cleaning are all reduced. Also the security of a dwelling unit from vandalism can be affected by the total outside facing exposure.

The environments of many high density housing areas are degenerative and debilitating. The effects of heat stress in the hot summer months can be very real, and such stress plus sleeplessness is the expected result of a hot spell. What is perhaps worse, however, is the necessity for open windows throughout the summer months in order to seek heat relief through the hope for natural ventilation. This, of course, exposes the apartment dweller to polluted air and destroys his privacy. It exposes the family unit to a cacophony of sounds including squealing wheels, an assortment of TV channels operating simultaneously, and the conversation and noise of neighbors.

On the other hand, complete air conditioning and the type of building which is made possible because of it, could give the family unit the privacy which it needs and freedom from the constant impingement of neighbors, noises and airborne pollution. In addition, by making the home comfortable, families may be kept together with the opportunity of freeing children from degenerative influences.

The complete control of environment based upon full air conditioning is not a feature or an appliance that can be added to or deleted from the building structure at will. Of real importance is the fact that it frees the architect of the restraints which are imposed upon him by the effort to alleviate summer heat suffering through natural ventilation. Innovative architectural design is possible and in its most simple form might take the shape of dwelling units that are long and narrow, with minimal outside wall exposure for the principal room, other living spaces being internal. But this is not a very imaginative use of this new freedom. Why should these dwellings have window exposures looking out on the street? Why shouldn't the exposed side of the dwelling unit face upon a pleasant court which could create a feeling of privacy and provide for garden plantings?

One could visualize an extensive building, the outer boundaries of which would not be relevant. The dwelling units with low wall/floor ratio may have their principal rooms facing on a series of nearly private courts. These courts need not be mundane in the sense of the old concept of light courts, but rather should be designed as private gardens that take advantage of the movement of the sun through the year and from morning to evening.

Access shafts, which would incorporate stairwells, elevators and necessary services such as refuse handling, could be alternated with the courts in such a way as to limit the number of families employing any one access shaft, thus improving security and privacy.

In such a building the perimeter would be somewhat meaningless. Therefore, where the terrain is suitable, a part of such a building could actually be below the ground level, since the occupants of the dwelling units would have no way of sensing whether they were above or below a remote ground level. This principle would permit walk-up and walk-down multiple dwelling buildings without expensive elevator systems.

The nation's goal in housing should be the construction of 3 million or more housing units each year in the near term, and by 1994, it is predicted that we should see more than 4 million housing starts per year, or more than three times the current rate. It seems certain that the existing construction industry and construction labor force is incapable of producing at the required rate. The outlook for increased productivity with existing methods is miniscule, as over the past 10 years the productivity increase in the construction industry, even with the advent of modern equipment, has been only about 4/10 of 1% per year, a small fraction of the productivity gain rate in manufacturing.

This leads to the conclusion that we must look forward to a substantial change in building methods in order to obtain the benefits of modern manufacturing practices and reduced on-site skills. And this is why the air-conditioning industry could well get involved, for no industry more explicitly demonstrates the efficacy of the United States' manufacturing enterprise under competitive challenge than does the air-conditioning industry.

In the short space of the past 10 years, through constant attention to product development, this industry has lowered the equipment cost for an average 3-ton residential system more than 35% and this was during a 10-year period during which manufacturing wage levels rose 33% and material costs rose 30 to 60% with the material most closely associated with refrigeration – copper – rising more than 200%.

Similarly, over the past 10 years, the cost of a representative electric driven water chiller in the 500-ton range has been reduced 30% in the face of the same rising material and labor costs – a remarkable achievement.

It might be observed that the actual total installed cost has been reduced even further since the newer products have been designed in such a way as to eliminate much on-site skilled labor.

It would seem that the mechanical/electrical components for the housing of the future provide a very appropriate area in which to apply the skills of the manufacturer, including his effective product development capabilities. Since the air-conditioning industry must be deeply involved, it would seem appropriate that our interests become broadened so that we look at more of the total problem, rather than simply cooling or heating. Based on these observations, I look forward to substantial changes in this industry and in its relationship to the whole construction industry over the period of the next 25 years, with new products and building system components involving our arts, being developed with a continued reduction of job-site skills.

Looking toward 1994, we can foresee a steady growth in the installation of air conditioning at a rate well in excess of the growth of the economy as a whole. More than 300 million tons of air conditioning will be in use in the buildings of that time as compared to perhaps 70 million tons today.

This growth projection can be justified not only by the need for air conditioning as a solution to the problems of urban housing, but also by the remarkable increase in affluence which can be foreseen for the average American. In this year of 1970, it is predicted that our gross national product (GNP) will reach an annual rate of $1 trillion. However, by 1994, a $4 trillion GNP is predictable and of some interest is the prediction that 25% of that sum will be spent for education as opposed to 6% of our current GNP. To put this gain in proper perspective, it should be pointed out that one-third of the 3-trillion-dollar gain will be inflation of the dollar, at a normal rate.

Of even greater significance is the fact that family purchasing power will become progressively greater and more widely distributed. The GNP per family in 1994 will be almost double that of today in constant dollars, and by 1984, 15 years out, more than 50% of our households will be earning more than $10,000 per year in today's dollars, vs perhaps 25% enjoying that status today. This outlook for affluence indicates that we can foresee an accelerating acceptance of air conditioning for residences, manufacturing plants, and other markets which are presently at relatively low saturation levels.

This expanding affluence also indicates that we will see an increasing acceptance and demand for convenience foods and luxury foods, and even synthetically manufactured foods, the processing of which will involve refrigeration systems of substantial complexity.

Looking ahead, one does not have to be much of a prophet to see that the next 25 years are not going to be all Utopia. A most serious problem that will apparently be growing in parallel with all of this progress is the effect of pollution: air pollution, water pollution, noise pollution, thermal pollution and waste pollution. I suppose we could summarize all this as "people pollution." It is significant that most of these areas of pollution either do relate or could well relate to the broad scope of technology embraced by engineers who are members of ASHRAE.

For example, in the area of electric power generation it is expected that by 1994 the needed capacity could well be three times the present demand. A necessary adjunct to the generation of electric power is rejection of heat, and we must conclude that the rejection of heat in quantity may represent another pollution problem. A projection would indicate that by 1990 the condensers of generating plants will be rejecting so much heat as to require one-third of all the fresh water flowing in the United States if water were used for the heat sink.

It should give us some pause to consider that for every ton of refrigeration we install, between the refrigeration condensers and the condensers of the generating plant that provides the power for the refrigeration and its auxiliaries, we must reject 25,000 to 30,000 Btuh/ton. Applying this figure to the 300 to 400 million tons we see in use by 1994, leads us to a startling quantity of heat rejection, enough heat, in fact, to raise the temperature of all the water flowing over Niagara Falls to the boiling point. Thus, we may have a pollution problem that we will not be able to blame on someone else. On the other hand, perhaps we can devise some beneficial use for all this heat. For example, it is reported that seaside power plants cause shrimp and oyster beds to thrive, and the possibility of utilization in food production should not be overlooked.

In other areas, too, it would seem that our profession has an opportunity to contribute. For example, the whole matter of combustion efficiency and the improvement of combustion processes to forestall polluted air and the pollution-free combustion of solid waste material represent potential areas for our attention. Finally, the technical expertise relating to the removal of airborne dirt and contaminants would seem to be definitely within our sphere of interest.

ASHRAE Presidential Member Crosby Field wrote an article for the October 1969 issue of ASHRAE JOURNAL which I highly recommend to those of you who have not yet read it. It is entitled It's Urgent! The Engineer Should Recognize His Responsibilities, and concludes with this statement: "We ASHRAE members, the original pioneers in air treatment, dare not stand still else we fail to protect the entire engineering profession . . . ." As to the relationship of ASHRAE to these problems, he had this to say: "What has this to do with the work of ASHRAE members? Simply that we must broaden our activities, not to take over any responsibilities of scientists or engineers in other fields, but to work hand-in-hand with them. We have been pioneers in air treatment, let us continue to be such." I believe that he has defined an important future role for the members of this Society.

Turning now to the future of energy sources, the electric utility industry forecasts continued growth of generating capacity at a rate that approximately doubles every 10 years. From a present-day capability of approximately 300 million kw, capacity will reach 854 million kw by 1985, and presumably by 1994 would be well in excess of 1 billion kw at peak. Of some significance is the fact that of all the new generating capacity which will be added, nearly 60% of it will be nuclear. By 1980 approximately 36% of all electric energy generation will be from nuclear power. Looking toward 1994, it is possible that technological improvements may finally result in nuclear power plants that are so safe, clean and economical that they can be located closer to the points of consumption, thus reducing transmission problems.

As to the gas industry, steady growth is predicted, even though in the near future a problem looms because the industry seems about to run short of product. Last year, for the first time, accrued reserves of gas in the United States declined as production exceeded new discoveries. Nevertheless, over the long term, this dilemma will undoubtedly be corrected. As it becomes economic to do so, the deficiency will certainly be eliminated by further exploration as there seems to be a conviction that there is no shortage of gas reserves beneath the ground. Alaskan fields alone present a large, actually unmeasured potential. Great strides in the technique of liquefied natural gas (LNG) can be expected and already there are plans to import LNG from Algeria and other foreign sources. The great gas fields in Libya are being tapped by United States technology to provide energy gas for the Genoa/Turin/Milan areas of Italy by means of liquefaction and liquid natural gas transportation. The liquefaction and transportation of LNG is really another advance in the art of refrigeration. Huge plants provide the refrigeration for the initial liquefaction and refrigeration principles are employed in assuring its safe transit.

By 1994, it is expected that economical plants for producing gas from coal or lignite at the mine site will be practical. The successful development of mine-side gasification plants would be the equivalent of increasing proved reserves by 40 times. Actually, a pilot plant for a process developed by the Institute of Gas Technology is scheduled to go on stream later this year, producing pipeline gas from coal. Another technique that may assist in improving the reserve situation is the use of nuclear blasting of gas-bearing rock formations. An experimental blast of this type was made recently in the Rulison field in Colorado.

Thus, looking forward from this date with respect to energy for cooling and heating, we can see no drastic trend since the present dwindling of gas reserves will almost certainly be reversed by other developing techniques. Nevertheless, it would appear that the long history of steadily lowering energy costs which really has gone counter to all other cost indices may be reversed because of higher capital costs and carrying costs, as well as the expectation of more expensive methods of production and distribution.

Our discussion has been predicated on our bringing the rampant inflation of recent years under control. Failure to cope with inflationary wage settlements far in excess of productivity gains will lead to disaster in the '70's and all these fine predictions will be worthless. Worldwide economic chaos would almost certainly result from continued inflation at the current wild pace with business depressions, the stagnation of industry and technology, and probably serious politcal crises. Obviously our discussion also assumes an absence of global war over this 25-year period.

These predictions are pointed at the domestic scene and this could be misleading since it seems likely that in the next 25 years our markets are going to become more and more global rather than domestic. Most of our industrial corporations will be exporting American technology and administrative capability, if not products, on a worldwide basis and it is more than likely that overseas operations with their 7 billion consumers in 1994 will eventually overshadow the domestic market which in that year may comprise 1/3 of a billion people.

Returning now to the future of the technology in which we are engaged, I have already suggested that it was probably inevitable that we broaden our interests, particularly in the direction of the control or alleviation of air pollution and again, in the area of housing needs, to the extent that our skills relate to the solution of these problems. Looking ahead technologically, it is difficult to envision any really startling developments such as entirely new thermodynamic cycles related to refrigeration or heating. Thermoelectricity remains a potentially important cycle, but one where the potential can never be realized without the discovery of some presently unknown thermoelectric materials. At the present stage of development, the inherent inefficiencies as compared to vapor cycle refrigeration relegate the principle to a minor role involving highly specialized applications.

It seems almost certain that technology already in existence will be applied to provide refrigeration cycles that will perform with substantially higher efficiency than those in common use today. Whether the energy source be fuel or electricity, I believe that considerable improvement will be made in our systems to the end that economy of operation will show progressive improvement. Heat recovery cycles will become highly refined.

A continuing trend toward large central plants furnishing heating or cooling to groups of buildings will certainly dictate the development of larger water chilling machines than are presently available.

It also seems reasonable to expect that some of the research in combustion methods will bear fruit in the years just ahead and provide us with higher efficiency, more compact methods of heat generation, and better flue gas quality from the pollution standpoint.

Finally, it seems that the most profound change in our technology will be in the direction of improving the functional performance of our products and systems. Presidential Member Daniel D. Wile, in delivering the Plenary Session address to this Society in July of 1969 (August 1969 issue of ASHRAE JOURNAL). had some deservedly unpleasant things to say about the performance of air-conditioning apparatus as it sometimes comes through to the man in the street. I want to mention a few areas that need serious attention for improvement and I think it is fair to say that no great technological breakthrough is needed to accomplish the needed improvement:

1. **Winter Humidity.** Regardless of what our comfort charts say, the average air-conditioning installation must be faulted on the point of winter humidity control. Whenever the outside temperature drops below 30 or 35 F, the relative humidity in most air-conditioned spaces gets progressively lower so that our customers wind up with dry nasal passages, or they have to sleep with open windows and frigid blasts to relieve the dryness. They get charged up and then jolted out of their skins when they touch a door knob. Our practices were better 25 years ago when washed-air central apparatus was widely used. It is no defense to say that buildings are not built to stand proper humidity because we should take a responsibility for the whole problem. Thus, if necessary, we should tell the architect what to do.

2. **Summer Humidity.** With most of our packaged systems, the only time the relative humidity is at an acceptable level is when load conditions are beyond the capacity of the machine so that it runs continuously. Otherwise, with the simplistic on/off control normally used, we treat our customers to periodic excursions of relative humidity levels of 75 or 85%, and finally, when the sensible cooling load is very low, a time when the moisture load is generally high, we get practically no dehumidifying at all, and then we really give our friends the damp treatment. Not that we do not know how to do better! After all, the bypass control principle was invented in 1924 and practical forms of reheat control were known and used 30 years ago.

3. **Temperature Control.** A substantial portion of our installations are deficient in the sense that the temperature control is too crude from a spatial standpoint. A single point of control in a 10-room house really cannot give desirable conditions in each of the 10 rooms. Similarly in commercial practice, how often do we find 10 offices on a single zone with a thermostat in the boss' office, or under a corridor outlet.

4. **Intermediate Season Performance.** Many people who operate our systems as well as some who design them seem to labor under the illusion that cooling is for the summertime and that heating is for the wintertime. Of course, the truth is that with modern lighting intensity and other internal heat gains, we may, in most localities, require cooling on any one of the 365 days of the year. If we cannot get operating personnel that understand this, we should then design our systems so that they are automatic and the decision is taken out of their hands.

5. **Noise.** I remember surveys being conducted 15 years ago among owners of room air conditioners to get their vote on what they would like to see improved. Reduced noise was the number one choice. In the intervening years, however, it would seem that only minimal improvement has been effected. Similarly, with other air-conditioning products, there is opportunity for progress in lowering sound output. Sometimes this annoyance may be augmented because the noise generated is intermittent. Perhaps there is a communication gap between the designer and the marketplace. On the other side of the coin, we should recognize that an important benefit of air conditioning is the elimination of noise pollution. Air conditioning permits closed windows, shutting out traffic noises, jet noises, and even the 99 dB rock music favored by a potentially deafened generation.

Thus, as to the technology of the future, I really must conclude that our greatest progress can be accomplished by rediscovering some of our lost art in order to bring our products and systems to a high level of quality and thus provide an ever-increasing degree of final customer satisfaction. Along with these objectives, we must also accept the prognosis that skilled operating personnel and maintenance and service personnel will become progressively more scarce and therefore our product and system design must be oriented toward high reliability, minimized maintenance, and automatic programming and operation.

As to the broader outlook for science and technology, in the next 25 years it seems almost certain that we will experience conceptually fantastic discoveries or synergistic developments that will certainly rival the scientific revolution of the past 25 years. We can only speculate as to the impact on our own technology but certainly, as already noted. the expected advances in automation and cybernetics will be applied to our systems to make them more independent of human resources.

A likely development which we must view with some misgivings is the expected proliferation of synthetic drugs for the control or stimulation of the mind. It is likely that many of these compounds will be adapted to airborne dispersion, and I can only hope that they will not propose employing air-conditioning systems for this purpose.

To bring this discussion to a close, I want to recall to my contemporaries that 25 years ago the air-conditioning industry looked exciting and full of glorious opportunities, and our unfolding technology possessed a fascination that was irresistible.

In these days, I sometimes get the impression that those who helped pioneer in the development of this great industry are feeling a letdown. Observing the glamour of aerospace projects, nuclear science, electronic physics, and other popular modern fields, perhaps there is a disposition to assume that we have reached some sort of static level of mundane success.

I beg you to dismiss such thoughts as we look to the future on this 75th anniversary of ASHRAE. From this vantage point, the next 25 years should look at least as thrilling and full of challenge and opportunity as the vision we saw in 1944. Major air-conditioning markets such as residential housing and manufacturing plants are at a low level of saturation and in the decades ahead we have a rapidly developing world becoming a real super market, the magnitude of which is 20 times as great as anything we have experienced.

Finally, there are important challenges ahead for our technical capabilities and almost unlimited opportunity to contribute to the solution of our nation's present and future problems of environment. To any young man seeking a truly satisfying career, we can say with confidence: Join us in this young and growth-prone industry. We offer you, with us, the opportunity to leave your mark upon this world to the betterment of mankind's lot.