Proceedings of A

Housing and Heating Conference

November 14, 15, 16, 1945

The Pennsylvania State College, School of Mineral Industries

EDITORIAL NOTE:

For purposes of style and clarity and in an effort to eliminate errors and ambiguities, each manuscript was carefully edited before going to the printer. This necessitated rewriting parts of several manuscripts by the editor who exercised every possible care so as not to alter the ideas or intent of the authors. Galley proof was submitted to all the authors who could be reached without unduly delaying the final printing. Most of the authors, therefore, had an opportunity to examine the revised copy.

J. D. CLENDENIN, *Editor*

STATE COLLEGE, JULY 8, 1946

THE PENNSYLVANIA STATE COLLEGE BULLETIN

VOLUME XL — February 8, 1946 — NUMBER 6

Published weekly from January to October inclusive. Entered as second-class matter at the Post Office, State College, Pa., under Act of Congress of August 24, 1912.

STATE COLLEGE, PENNSYLVANIA

Acknowledgments

This Housing and Heating Conference was made possible through the unstinting effort and interest of many individuals and organizations.

Especial thanks are due to each and everyone who contributed a paper or discussion during the conference, and gave his valuable time in preparing manuscripts for these Proceedings—their names appear in the text of this publication.

The help of the Conference Committee and the chairmen of the meetings is gratefully acknowledged, for it was invaluable; and last, but not least, the interest of the cooperating organizations is appreciated. The personnel and membership of these three groups follows:

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Address of Welcome

By the Honorable Richard Maize*

It is a privilege and pleasure to welcome you to this Housing and Heating Conference sponsored by the Division of Fuel Technology of the School of Mineral Industries of The Pennsylvania State College. It is fitting and proper that you should gather here in the geographic center of the great industrial State of Pennsylvania for this Conference, where old Mount Nittany looks down on the beautiful valley in which this great educational institution has been built.

The Pennsylvania State College was organized as a land-grant college in 1859—86 years ago, and from these halls and classrooms has sent out into the world thousands of Pennsylvania's sons and daughters, as well as the sons and daughters of many other states in the Union, to make their mark in the world and bring honor and glory to their alma mater.

I repeat, it is fitting and proper that you should meet here under the auspices of the School of Mineral Industries because this unit of The Pennsylvania State College is one of the pioneers in research for the development and improvement of housing and heating facilities. Doubtless, you will have an opportunity, while here, to see some of the work being conducted by our staff under the able leadership of Dr. A. W. Gauger, our Director of Mineral Industries Research.

In seeking something appropriate to say to you who are gathered here to discuss mutual problems in and examine the future of housing and heating, I am not unmindful of the work you, and others like you, have done in the past, because the heating engineers of this country are the unsung and unapplauded heroes of the engineering profession. You have done wonders in assisting Old Mother Nature to increase her coal reserves. The coal reserves of this and other countries have been increased by many millions of tons without, in any way, increasing the coal stored in the bins of Mother Nature. This has been done by increasing the efficiency of burning equipment, not only in homes, but also in industrial plants, and the general public knows very little about the work you are doing.

When a great building has been constructed, or a great dam has been built, or a great river has been spanned by a huge bridge, or some other great engineering feat has been visualized and then put into reality by civil, electrical or architectural engineers, a nameplate is placed on the edifice, acclaiming to the world the names of those who created and constructed it. But the engineers of the heating industry have gone along in their own quiet way doing as much, or more, for the human race in conserving its natural resources as the engineers have done in constructing the great buildings and bridges.

Coal is one of Nature's greatest gifts to man. It has brought more benefits, more comfort, and more relief to the human race than all the other minerals of the earth combined. We could get along without gold and silver,

* Secretary of Mines, Commonwealth of Pennsylvania and Trustee, The Pennsylvania State College.

diamonds and rubies, for they add only to the pleasures of man. But coal—the black rock which we dig from the bowels of the earth—is the one mineral which has done so much for our comfort, health, and safety. Had it been lacking we would have been prevented from developing our high standards of civilization; moreover, it is the one mineral which, when utilized for the benefits of mankind, is destroyed forever.

Gold and silver coming from the earth, always remain as gold and silver no matter what is done with them. Diamonds, after being mined and polished, add to the beauty and delight of the eye, but they do nothing for the human race that is comparable with coal. Even sandstone, limestone, fire-clay and gravel, and like materials coming from the earth, always retain their identity or are retrievable. But coal, when put to work for mankind, loses its identity, is irretrievable, and irreplaceable.

In addition to the comforts we obtain as a consequence of the heat derived from coal, there are many other products with which you are familiar, and it is needless to enumerate them here.

I was attending a coal conference a number of years ago in which engineers and chemists were describing the many things that could be made or derived from coal. One of them stated that the point had been reached where even butter could be made from coal. In my remarks as the next speaker, I said that I could go the previous speaker one better—"*I* had been making both BREAD and BUTTER out of coal for the past 40 years."

In conclusion, I, as a member of Governor Martin's Cabinet, and a Trustee of The Pennsylvania State College, and on behalf of the Governor of the Commonwealth of Pennsylvania and the President of The Pennsylvania State College, welcome you to this Conference, and I sincerely hope that you will enjoy your visit and the beauties of Nittany Valley so much that you will want to return in the future for another conference.

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Opening Remarks

By Edward Steidle*

I AM sure that it gives all of us a full measure of personal satisfaction to see the Housing and Heating Conference materialize. I watched your plans unfold with genuine interest; I was struck with the idea, the timing, the program, the service to be rendered. It promises to be one of the best all-around conferences of its kind, and I take my hat in hand to all of you.

Professor Spicer asked me to say a few words about the organization of the School of Mineral Industries at this time. We envision the mineral arts and sciences as a distinct inter-related, inter-dependent division of higher education. The subject matter divisions are: Geography, Geology, Geophysics, Meteorology, Mineralogy, Petroleum and Natural Gas, Mineral Economics, Mining, Mineral Preparation, Ceramics, Fuel Technology, Metallurgy. These divisions are classified under three departments: Earth Sciences, Mineral Engineering, and Mineral Technology.

The Earth Sciences are concerned with those divisions of natural science which relate specifically to the earth, its origin, constitution, and evolution. The term Earth Sciences is a direct translation of "geo-logy."

Mineral Engineering is concerned with extracting minerals from the earth and preparing them for use. In other words, it is the means by which mineral matter, including mineral fuels, is made available to man.

Mineral Technology is the applied systematic knowledge of primary methods of processing and treating mineral matter and directing its industrial utilization. It is concerned with those industrial arts and sciences which involve the transformation of mineral fuels into energy and the conversion of minerals of all classes into raw materials of industry or finished articles of commerce.

A new plan of organization to meet future needs of the mineral industries was approved by the College Board of Trustees in January 1944. The new plan provides greater opportunity for unity in policy and purpose, and more integration of programs, and points the way to productive work in Pennsylvania on a basis of perpetuity, as well as immediate postwar economy. The Executive Committee, composed of the Dean, Directors, and Department Heads, sets the course of the School. The Dean coordinates the over-all School program and concentrates his efforts on undergraduate training. Directors of Extension Services and Experiment Station work through department heads toward their respective objectives. Heads of departments, for all practical purposes assistant deans, integrate classified divisions of work. Chiefs of divisions are key men and give close attention to student personnel and guidance. Budgets and records are simplified, and research foundations, such as Glass Science, Inc., can be accommodated under the plan.

The School of Mineral Industries is the only one of its kind equipped with specialized apparatus and trained personnel now engaged in solving the educational and technological problems of a Commonwealth concerned with its mineral resources. Moreover, it is the only unified School offering all three functions of service; namely, resident instruction, extension instruction, and research. The School does not differentiate among these three. All are educational services that must be coordinated for effective application to the mineral industries of the Commonwealth.

As far as we know, our curriculum in Fuel Technology is the only one of its kind offered in the United

* Dean, School of Mineral Industries, The Pennsylvania State College.

States. The gap in the training of technical leaders and skilled workers caused by Selective Service must be filled. Veterans with a background in fuel technology must be educated back into this field of work. The supply of graduates has never exceeded the normal demand, even during the depression years.

In conclusion, I wish to say on behalf of President Hetzel that we are happy to have you on the campus. There is no apparent reason why the conference will not go over with a bang. I understand that the published proceedings will embrace both papers and discussions. Please make yourselves at home in the Mineral Industries Building and take advantage of the "open house" which will give you a chance to meet some of our key men and see for yourselves what is going on.

The Dynamics of Housing and Heating Equipment Demands

By K. C. Richmond*

JUST as long as human nature is what it is, "housing" is going to be anything but static. Change is our only constant. Neither people, nor products, nor markets stay put, for ours is a dynamic economy. Invention put civilization on wheels, a can opener and a refrigerator in the kitchen. The Model T gave way to the Model A; last year's models give way to this. New products, new inventions come on the market, supplant others. Wants and requirements change; new needs develop. Dissatisfaction, discontent and a desire for a change—these create much of our market potential. Customers are here today and gone tomorrow. Changes in the rate of population or industries' growth affect sales volume. Legislation, regulations, and taxes affect the cost of production, transportation, distribution, and sales; hence, real income and purchasing power—or who buys what.

SOME BASIC FACTORS

Consequently, in considering housing and heating demands, we have no choice but to recognize such factors as these:

1. The basic needs and accumulated deferred demands.
2. Growth in population, marriage, and birth rates; reduction in the size of families; increase in the span of life; the return of G. I. Joe.
3. Various shifts in population, migration, decentralization, suburbanization.
4. Current availability and status of housing, its age, condition, maintenance, obsolescence.
5. The construction records.
6. The economics of housing—rent in relation to income, and as a stimulus to new construction for the investor—building incentives—availability and cost of material, labor, land; the effect of building codes and zoning, taxes, "politics," jerry-building and slum clearance.
7. Employment, purchasing power, real income, comparative prosperity—confidence in business conditions in general, and the building cycle in particular—complicated by the inevitable uncertainties.
8. Credit—ease of financing, interest rates.
9. Technological developments in housing, building materials, construction methods, possibilities of reduction in housing cost—and changing psychological demands.
10. The time element.

That housing is a basic need, that we need more housing, and that housing construction hasn't kept pace with growing needs is obvious. But suppose we document the situation in the following paragraphs.

GROWTH IN POPULATION

In 1920, our population was 105,710,000; ten years later it was 122,775,000—an increase of 16.1 percent; in 1940 it was 131,669,000—an increase of 7.2 percent over 1930. Today, it is 140,000,000—an increase of 6.3 per cent in the five years since 1940.

THE MARRIAGE RATE

In 1939, we had 1,375,000 marriages; in 1942, there were 1,758,000. For 25 years, the marriage rate has run approximately 10.57 per year per 1000 population Since 1919, we have had over 33 million marriages in the United States, an average of 1,280,000 per year. Between 1940 and 1950 the number of marriages may be expected to total 15½ million. By 1950, we prob-

* Editor, *Coal-Heat Magazine,* Chicago, Ill.

ably shall have some 40 million families—5½ million more than in 1940.

THE BIRTH AND DEATH RATES

In 1943, 2,935,171 babies were born in the United States, which represents quite a market today and for a great many years to come. During 1944, 2,794,800 births were registered, to which you can add three per cent for those not registered.

Both birth rates and death rates per 1000 of total population are stabilizing, as you will note from the following figures:

	Births	*Deaths*	*Difference in Birth and Death Rates*
1915......	25.1	14.1	11.0
1920......	23.7	13.1	10.6
1925......	21.5	11.8	9.7
1930......	18.9	10.9	8.0
1935......	16.0	10.9	6.0
1940......	17.9	10.7	7.2
1943......	22.0	10.9	11.1
1944......	21.1	10.6	10.5

This net gain in births over deaths, coupled with the marriage rate, 18 to 25 years later, results in an added increment in housing demand of not less than two new dwelling units per year per 1000 population. Many of the babies that were born between 1920-25 have grown up, been married, had children of their own, and are now ready, or will be in the next few years to buy or build homes of their own.

SMALLER FAMILIES

Dwelling units are getting smaller, because families are shrinking in size and the proportion of older persons in the household is rising, the Federal Home Loan Bank Board has reported. The Board reports:

> "Of all population trends, probably none has greater significance to the housing market than the number and size of families, for housing demand is largely determined by these two factors. On April 1, 1940, the number of private households, which corresponds closely to the number of families, was 34,860,000. It is therefore estimated that during the 'thirties, there was a net gain of some 5,000,000 families, or 16.6 per cent, as compared with an increase in total population of only 7.2 per cent.
>
> "Over half of the increase in the number of families during the 'thirties resulted from a decrease in the average size of family from 4.1 to 3.8 persons. A drop in family size has been revealed by each census since 1890. Just as the number of families is a major determinant of the number of dwelling units needed, the number of persons in the average family decides, in the main, the size of units to be built."

This reduction in 10 years in the size of the family has resulted in an increased need of 19 dwelling units per 1000 persons—or from 244 to 263 per 1000. This means that it takes 7.9 per cent more dwelling units than in 1930 to accommodate the same number of people—70 per cent more dwelling units would be required than in 1850, when the average family was composed of 6.5 persons.

"DOUBLING UP"

Back in 1934 and 1936, when the Real Property Inventory was being taken, the percentage of "extra families" reported was 5.5—8.9 in the Southeast; 5.1 in the Northwest; 8.6 in the Southwest; and 4.0 in New York City.

In other words, in 203 towns or cities, 7,970,000 families occupied 7,093,000 dwelling units. This means that nearly one dwelling in seven had an extra family living in it. The situation also has probably been considerably worse in many of our war congested areas the past few years.

With our high marriage and birth rates and the lack of housing construction the past few years, it is safe to assume that "doubling up" will continue to increase rapidly as several million men come back from the army and navy. Too many service men are unable to establish homes, and it's going to be three or four years before we can hope to meet even part of the accumulated housing demand.

CHANGE IN SPAN OF LIFE

Back in 1900, the average life expectancy at birth was 47 years. By 1930, this had increased to 60 years, and in 1940, it was 63. With a 35 per cent increase in the number of persons over 65 years of age—since

1930—the actual demand for housing is obviously greater than it was 20 years ago.

By cities, the number of persons above the age of 65 increased between 1940 and 1943, respectively, as follows: Atlanta, 22,556 to 25,772; Buffalo, 60,699 to 64,450; Charleston, West Virginia, 7,957 to 11,077; Cleveland, 67,430 to 74,664; Indianapolis, 32,236 to 35,475; Louisville, 32,623 to 35,804; St. Louis, 99,357 to 116,171; Salt Lake City, 12,247 to 14,081.

As of 1940, 6.8 per cent of our population—or nearly 9 million persons—were over 65 years of age. How many of these were occupying separate dwelling units or were doubling up with their children, I don't know, but it seems safe to assume that this increased span of life has increased housing requirements.

SHIFT IN POPULATION

Not only have we had a large increase in population, but also a distinct shift in population from farm and rural non-farm areas to urban communities which, likewise, has affected housing needs. For example, in 1880, 28.2 per cent of our population lived in cities; in 1890, 35.1 per cent; in 1900, 39.7 per cent; in 1910, 45.7 per cent; in 1920, 51.2 per cent; in 1930, 56.2 per cent; and in 1940, 56.5 per cent.

AGE AND OBSOLESCENCE

Study of the latest Census of Housing figures shows that 3 per cent of our dwelling units, nationally, are over 80 years of age; that 4.4 per cent are from 60 to 80; that 5.6 per cent are from 50 to 60 years of age. One might say, then, that 13 per cent (or one in eight) of our dwellings are obsolete—based on age and that replacement needs are increasing very rapidly.

DEPRECIATION

Physical deterioration of both buildings and neighborhoods can be obvious to the novice; natural wear and tear, dry rot, termite infestation, cracking of foundations and sidewalks, corrosion, lack of paint, and neglect—all of these—are accumulative. Moreover, coupled with functional obsolescence in design, equipment under improvement, and the "element of inadequacy," or suppression, many buildings have long since become out-of-date. Hence, depreciation, physically, functionally, or economically, is no small factor in the dynamics of housing demand.

LIFE EXPECTANCY OF BUILDINGS

The economic life of many buildings is much less than might be assumed. According to studies by the National Association of Real Estate Boards for the U. S. Treasury Department, the period of usefulness of single-family frame dwellings has been found to be 33 years; frame row house, 30 years; two-, three-, and four-family dwellings from 30 to 40 years, hotels and elevator apartments, 22 to 35 years. Thus, judged by the criteria of technological obsolescence, the housing market is literally unlimited.

THE DEMOLITION RATE

The availability of dwellings is reduced also by fire, old age, and demolition. According to William Wittausch of the Federal Housing Administration, these have reduced the amount of housing at an average of 1.6 per thousand dwellings per year.

What the "abandonment" rate is—no one knows. Certainly, there are many buildings that are not occupied, owing to their age, condition, or location. More of the war housing stands idle today than might be expected, and this percentage is likely to increase materially, as some of our war-boom towns or cities return to normal. The effective life of a lot of cheap housing hasn't been anything to brag about, obviously.

WHAT SOME OF THE RECORDS SHOW

In 884 cities, representing 90 per cent of all the cities in the United States with a population of 10,000 or more, the average annual gains in new housing units were 1.5 per 1000 population for the years 1929 to 1935. This, as we have seen, is by no means sufficient to take care of the growing needs for housing. Between 1936 and 1938, the gain in family accomodations in cities of a half million or more averaged 3.5 units for each 1000 population. In the three smaller city-size groups, the ratios ranged from 2.2 to 2.5 according to governmental data.

THE ANNUAL BUILDING RATE

Based on the number of dwelling units in nonfarm areas at the end of each decade, it has been estimated that our average annual percentage increase has been 2.6 between 1900-1909, 2.1 between 1910-1919, 2.8 between 1920-1929, and 1.4 between 1930-1939, or 2.1 for the period of 1900 to 1939. The nation's biggest residential building year (1925) produced 930,000 new units. The low point was reached in 1933 with 93,000 units, and the 1920-29 average was 700,000.

WHAT THE NEEDS ARE

According to findings of the Temporary National Economic Committee in its report on housing a few years ago, the market called for some 600,000 non-farm dwelling units a year—340,000 to accommodate population growth, 45,000 to replace those purposely destroyed, and 215,000 to replace those units now suitable, but which will wear out in time. (And these figures did not include fire or tornado losses, nor cover desired replacement of the 4 million or so of the nation's substandard units.)

An estimate that 12,600,000 non-farm and apartment units will be required the next decade "to meet the needs of American families and to make substantial progress in replacing substandard structures" was made recently by the National Housing Agency.

John B. Blandford, National Housing Administrator, said the estimate of postwar needs represented an "earnest effort to judge the size of the nation's housing needs." Replacement of substandard structures in 10 years would require 16,100,000 units, but NHA assumed the replacement job would be spread over 20 years.

SLUM CLEARANCE

Such factors as blighted areas, ill-advised land uses, obsolescence, high prices on run-down urban real estate, the trend toward living in the suburbs, coupled with depressions, politics, governmental low-cost housing activities—all have some bearing on the "dynamics of housing demand."

While there will be differences in opinion as to some details of William Lescaso's proposal to eliminate slums through building groups of "superblocks," few can object to his basic contention as to the necessity of freeing increasing millions of Americans now penned up in slums and providing them, at a minimum rental, with "sun, air, space, in ample proportion, for the enjoyment of life."

THE "VITAL" STATISTICS

While death and divorce may release two or three dwelling units per year per 1000 persons, this will accommodate only a fraction of the increased demand occasioned by our average annual marriage and birth rate. Therefore, we might assume that for every 10 couples that get married, we need seven or eight new dwelling units—which indicates a need of from 900,-000 to 1,000,000 new dwelling units a year.

Obviously, housing construction hasn't begun to keep pace with biology or the decrease in size of the family unit, let alone meet the normal replacement needs due to depreciation, obsolescence, fires, floods, and tornados. Consequently, we should build not less than three new dwelling units per year for every 100 families (11 per year per 1000 population), or around 1,500,000 a year nationally, based on the present population. Today, we could use several million more dwelling units to advantage—if we had them.

OTHER ASPECTS

Housing, of course, covers a lot of things besides brick, lumber, piping, roofing, etc. (some 30,000 items), and thus affects the use and sale of many appliances, or what have you. When one couple puts in a new "electric kitchen," remodels the bath room, or installs new heating facilities, it stimulates their friends and neighbors to do likewise. So, "keeping up with the Joneses" provides one of the strongest stimuli to modernization or the purchase of consumer goods.

A study of the Census of Housing statistics shows what our potentialities are: 42 per cent of our dwellings have central heating facilities, 34 per cent are cooking with wood or coal; 50.8 per cent have private bath; 69.9 per cent have running water; 59.7 per cent have private flush toilets; 32 per cent outside toilet or privy; 78.7 per cent have electricity or lighting; 44.1 per cent have mechanical refrigeration. But, there is one thing we must remember—that neither people nor markets are just figures or statistics; it's what people do, or what they think, that counts.

ECONOMICS OF HOUSING DEMAND

Whether people buy or build, or don't, depends very much on personal income, effective purchasing power, anticipated income over a period of years, general business activity and national income, the psychological atmosphere — whether optimistic or pessimistic.

Whether people can "afford" to build or buy now, next year, or five years from now depends also on current land, labor, construction, and financing costs, on taxes, building codes, rental charges, and politics. Technically, we are making some tremendous advances in housing construction, materials and methods, but antiquated building codes, restrictive labor practices, and the inflationary cost situation are such that housing construction the next two years isnt likely to be one-third of what it might have been. Despite the needs, people aren't going to build new homes when material, labor, or other costs are out of line in comparison to their income. People just can't pay $10,000 for $6000 houses. Hence, costs or prices, as well as biology and psychology, are major factors in the dynamics of housing demand. This is true, also, with household appliances or equipment; note how the sales of electric refrigerators and stokers gained as the prices dropped. While prices on these dropped, the costs of housing construction, in general, have doubled since the early '30's.

Housing and heating needs are literally unlimited; the market is what we help make it.

CONSUMER NEEDS

Except for the consumers' needs, of course, we wouldn't have anything to sell; there would be no demand for housing, for heating equipment or fuel. Therefore, how successful we are as builders, heating equipment manufacturers, fuel producers, dealers, the next 10 years, depends on how we anticipate and meet the consumers' needs and wants for housing and heating, hot water and comfort.

From the public or consumer relations viewpoint, then, we might ask what percentage of home owners or renters are now enjoying the maximum in satisfaction? In considering the postwar situation, the coal man might ask why 250,000 dwellings—10 per cent of this State's total—are now using oil or gas? What percentage of the new homes or buildings that have been constructed in Pennsylvania the past 10 years are heated with solid fuels? What will be the situation in new housing the next five years? Such figures indicate that some coal customers, at least, weren't too happy with their heating results, or that someone came along and sold them on putting in oil or gas burners.

SOME FUNDAMENTALS

What we must remember is: (1) that the customer judges fuel by what he gets out of it; (2) that what he gets depends on how he uses it; (3) that neither our fuel nor equipment is any better than the skill of the operator; (4) that these are no better than the means of heat distribution, or what happens to the heat after it leaves the boiler. Hence, if members of the fuel and heating industries are to help insure the more satisfactory use and sale of their products, considerably more attention will have to be given to heating equipment and its use, to insulation and to proper coal storage facilities, as well as to educational efforts, both within the trade and among fuel users.

If you study the age of buildings in Pennsylvania, it becomes self-evident why some persons haven't been enjoying the maximum in heating satisfaction, or why some have changed to other fuels. According to the Census of Housing, approximately one dwelling in 20 was built prior to 1860; 22.4 per cent before 1889; 36.7 per cent before 1900; 21.1 per cent between 1900 and 1909; 15.9 per cent between 1910 and 1919. This means, then, that more than one in three is way over 45 years of age. The median age of farm homes in Pennsylvania is over 57 years. Notwithstanding that many of the older homes are of better construction than some of the new ones—too many of us have overlooked the fact that they become obsolete, that boilers, furnaces, or stoves do not last forever.

THE EQUIPMENT SITUATION

When you check the character, condition, and operation of the majority of heating systems, you find that only a comparatively small percentage of fuel users have any real conception of the many factors that affect their heating comfort, of what happens to the heat they buy, or what is involved in the selection, proper operation, and maintenance of the heating systems in their homes, buildings, or plants. Too many didn't get the type of heating facilities, chimneys, and coal bins they should have when they built or bought their homes (and many aren't getting them today—which explains why so many of us favor T. S. Spicer's "Comfort Seal" idea).

One reason for this is that half of the heating equipment, nationally, is in the basement or boiler room, out of sight, and people have been inclined to spend money where it would show. If heating plants stood at the curb where the neighbors could see them, maybe heating plants would get something of the same sort of attention that an automobile receives. Less than 20 percent of the heating facilities today are in good condition, 20 per cent in fair condition and 60 per cent or more in poor condition, which shows what a tremendous need there is for modern heating equipment. Less than 10 per cent of the heating plants, including those in apartment houses and janitor-operated buildings, are clean and are skillfully operated. Only around 20 per cent are fairly well operated. So, what can the coal industry expect in the face of such conditions?

THE HEATING EQUIPMENT REPLACEMENT MARKET

Is it surprising, then, that year in, year out, good or bad, four warm air furnaces out of every 100 in use are replaced annually? Likewise, out of every 100 boilers in use, two or three go to the scrap pile annually and are replaced. Don't forget that over 60 per cent of the furnaces and half of the boilers bought are for replacement use. Thus, one out of every 25 furnaces, one out of every 40 boilers, and one out of every 16 heating stoves in use in your territory, are replaced annually—and this has been the basic sales record since World War I. This means on the average that 30,000 building owners in Pennsylvania alone will replace their furnaces in any given year, 22,500 their boilers, and over 50,000 their heating stoves. Actually, two dollars out of every three that are spent for heating equipment go for repairs, replacement, modernization; hence, new housing represents only one-third of the market for heating equipment. (This State ranks third in the number of stokers in use, but it is first in the number of single-family dwelling units.)

Although many heating plants are replaced hurriedly following some emergency, the decision, probably, as to the type or brand of plant and the kind of fuel to use in these plants was made months or years before. Thus, every incident or factor that affects their use or results has some bearing on what the customer does when he replaces the old plant. Just because a customer hasn't complained doesn't necessarily mean that he is happy about his heating results. He may, and quite frequently does, put up with unsatisfactory heating results for quite a while, or until he finishes the payments on something or other, and then he buys from the other fellow.

Obviously, few fuel users are going to be happy indefinitely with antiquated or Model T type of heating systems, or with inadequate coal storage facilities. Thus, the coal man's success depends, to no small extent, on the heating facilities in his customers' homes or buildings, and on the replacement or modernization of a lot of equipment.

SOME THEORETICAL POTENTIALS

Based on the present status of the heating facilities in use in the average home today, and what is becoming available in new equipment, the residential building owners of this country could buy, to advantage in the next few years:

- 4.7 million new boilers
- 9.6 million new warm air furnaces
- 12 million new space heaters
- 20 million new water heaters
- 13 million new heat regulators
- 10 million new stokers, gas or oil burners

This, of course, represents no small volume of business, but much of it will have to be sold.

Since the period of gestation in the purchase or construction of a house is of the order of four years, it's the kind of heating service that people get today that influences what they buy tomorrow, or what they do when they build a new home, or modernize their old heating facilities, which is another reason why good customer and public relationships are so important.

THE STOVE MARKET

With 16 million dwellings in the United States heated with stoves (812,000 of these in Pennsylvania —or 32.7 per cent of this State's total—), the stove market deserves a lot more attention than it has been getting in most quarters. Only three states, by the way, have more heating stove users than Pennsylvania, namely, Texas, California, and Illinois.

Since many of the small houses that have been built in recent years (or will be in the future) are stove heated, it is high time that we recognize the stove market. For example, more than three times as much coal is used in coal stoves than in small stokers; more than 642,000 dwellings in this State are using coal as fuel for cooking purposes; and 119,000 are using wood.

HOT WATER

If there is anything that women want, it is plenty of hot water the year around, but most of us haven't been getting in on our share of this market. This is one of the country's most neglected markets, as we pointed out in COAL-HEAT (July 1945). If the coal man were to get this tonnage, it would add some 15 per cent to the present volume in the retail field—which is worth going after.

PROPER COAL BINS & CHIMNEYS

What some of us are also concerned about is how to get the right kind of coal bins, chimneys, and modern coal-heating equipment into more of the new homes. So, we were delighted to see this splendid Housing and Heating Conference emphasize some fundamentals—proper building construction, basements, chimneys, coal bins, modern heating facilities.

We face the problem of reaching and selling not only the prospective home builder, but also the speculative builder who decides, in more than half the cases, what kind of wiring, plumbing, or heating equipment goes into the new homes. Consequently, there is an educational and sales promotional job here not only for every progressive coal merchant and heating dealer, but also for the various manufacturers' associations and other agencies as well.

THE SOLUTION

If the coal industry wants to get a larger share of the fuel and heating business, it is self-evident that more members must get behind, or take on the sale of modern heating equipment — sell heat regulators, stokers, controls, stoves, furnaces, boilers, insulation, or what have you. If we look at things from the consumer's viewpoint, with a little imagination, there can be no question as to both present and future merchandising needs and opportunities.

Housing and heating markets are literally unlimited.

DISCUSSION

C. C. Wright presiding

E. R. KAISER[1]: First of all, I would like to congratulate those responsible for this Housing and Heating Conference. The list of papers and authors is indeed impressive. I am sure we will all benefit from what we shall hear and see at these meetings.

Mr. Richmond's paper on population trends and the great need for housing is most enlightening.

Every young couple wants to move into an attractive small house of their own right after the honeymoon. That is one of our great American ideals. Economic factors, principally lack of money, force young couples to move into rooms, flats, apartments, and old houses, or to move in with relatives. Many never attain their original goal, even in later life.

[1] Assistant Director of Research, Bituminous Coal Research, Inc., Pittsburgh, Pa.

Today, the shortage of acceptable housing is forcing us to do something to meet the need. Small, individual homes of attractive design could be built to utilize space more efficiently than in the past. With full or partial prefabrication, such houses should not exceed what young couples can afford to pay. The other alternative is the construction of apartment colonies of the type built in slum clearance projects.

At the present time we are faced with a manpower shortage and labor strife, the aftermath of the war, which cause a shortage of building materials and high prices for materials and labor that are available. This condition must be corrected before the public can purchase the housing it needs. In the meantime the housing and heating profession can develop designs and plans.

R. C. JOHNSON[2]: I feel that Mr. Richmond has done a fine job in presenting this paper in bringing out a number of very important points which are involved. I feel as Mr. Kaiser does that the full impact of our present shortage of housing has not been appreciated in Washington and also at the present time builders are having great difficulty in obtaining equipment. In fact, parts and materials, as far as we can see, are more difficult to obtain now than ever before. Therefore, it looks as though it will be a long time, unless we have control of materials, before the acute housing shortage is going to be alleviated. I believe the paper should be given wide distribution so everyone will recognize the immediate problems.

W. B. DIXON, JR.[3]: I think Mr. Richmond has touched on some very fine housing points. There were one or two statements with which I do not fully agree. These will be brought out in my paper later in the conference.

I don't quite see how the building industry can gear itself to a million and a half homes per year much before five years from now. The material situation alone is tremendous for such a proposed project. Our National Association has been fighting government agencies all through the war period for the materials to build homes. Today, these government agencies are trying to bring the government into the private building industry as has been done in foreign countries through public housing. The taxpayers should be acquainted with the true picture of the excessive cost of public housing.

I, too, feel that Mr. Richmond's paper should be brought before the people of the National Housing Agency, planning boards, and other officials who feel that government should do housing.

T. S. SPICER[4]: I was quite amazed to hear about the 30,000 items that Mr. Richmond mentioned in his paper that go to make up a home. I wonder if Mr.Richmond would care to venture a guess on the items that go directly into the heating system.

K. C. RICHMOND: Those of us who are dry behind the ears think of the heating facilities in terms of building construction, the distribution of heat, what is in the basement or boiler room. You can't separate them. Insulation is just as important in the house as the boiler or furnace. So is the chimney. What good is a heating system without a decent chimney?

The only reason I didn't discuss current building construction problems is because there are ladies in the room. It wouldn't be diplomatic to say what I think about some people in Washington, or elsewhere; they have been stupid, blind, etc. Look at our building codes, restrictive labor practices, the price situation!

But we have a situation that you can't disregard. The kids are going to grow up and get married. They are going to have children. Today, several million couples are living with their parents, and many are not happy.

We've got to cut the cost of building construction. We can use some factory prefabrication. The day is past when labor leaders should tell us what to do or not to do in building a house. We can reduce the cost of building materially. There is hope. But we can't continue to design and build houses the way we have in the past and keep the cost in line.

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2 Vice-President, The Anthracite Industries, Inc., Laboratories, Primos, Pa.

3 Director, National Association of Home Builders of the United States, Pittsburgh, Pa.

4 Assistant Professor of Fuel Technology, The Pennsylvania State College.

I agree with the National Association of Home Builders. They are doing a swell job. The demand for houses is going to increase. We can and should rise to the opportunity.

DISCUSSER FROM FLOOR: We have not begun to appreciate the hot water needs of this country. A third of the people in Pennsylvania are cooking today with coal and wood. We can give them something better. I am not a New Dealer. There is a market for the organization that is willing to spend money on research and develop facilities for low-cost homes. There is a swell market if we rise to it.

D. R. MITCHELL[5]: There is a trend going on in this country which I liken to a trend back in the covered wagon days. All you need to do is go down College Avenue and you will see what I mean —a trailer camp. The only difference between it and the covered wagon days is that the trailers are lined up in rows, not in a circle, and there are no Indians. But the point is this. You are not going to be able to sell coal, plumbing fixtures, building materials, heating plants, etc., if a high percentage of our population is going to be living in trailers. It is not right and I think groups such as this can probably make themselves heard to aid in correcting this condition. Let's get our people in homes by insisting that movements be started in this country so that returning G.I.'s and people just getting started in life have a decent place to live, and, of course, at the same time a market is created for fuel, heating, and building equipment. The sad part is that at the present, and for a few months to come, we do not see much of a way out, but I think and hope that we do not continue to put a good share of our population in trailers.

[5] Head, Department of Mineral Engineering, The Pennsylvania State College.

Building Design and Its Effects Upon Heating and Air Conditioning

By Kenneth J. Heidrich*

THIS subject is extremely broad in scope for the space allotted; consequently, it has been necessary to weigh carefully the various interesting possibilities for discussion. The many phases of the mechanical problems encountered in the heating of the skyscraper, the expansive one-floor industrial plants, auditoriums, and other special building types were eliminated in favor of the topic which I feel is most timely and of greatest common interest—the modern house.

The revival of earlier heating methods and their use in the house of today warrants at least passing reference to the historical aspect of the subject. In a study of the evolution of building design one learns how the spread of civilization from its tropical cradle to the colder climes has always been dependent upon man's ingenuity to provide for his protection from the elements. In fact, the heating consideration has been one of the fundamental concepts upon which much architecture has been based. Man's habitation in the torrid zones was made possible only after his discovery of the properties of building materials and of their combined use to reduce the effect of direct solar radiation. Mechanical cooling, as it becomes more economically available, and further advancements in heating equipment will surely be reflected in changes in building design.

Various principles or methods of heating have been evolved, used for a time, then discarded or forgotten, only to be revived or rediscovered at a later date. The present so-called panel or radiant heating, for example, was used about 2000 years ago in the Roman baths. Warm air was circulated through ducts to heat the floor which served as the convecting surface. Revived in England early in this century, panel heating has been widely utilized in Europe and its acceptance in this country has been on the increase during the past decade. Like panel heating, solar heating is also being popularized. It too is not a new idea but rather a readaptation of a long-known principle. Comparatively local application may be observed for instance in the Lancaster County barns, in which the second floor cantilevers or extends toward the south to provide a shelter for the stock. In the winter months, the low angle of the sun's rays permits solar penetration to the rear of the covered portion while in the summer because of the steeper angle, the space is almost entirely in shadow. Except for the addition of glass, application of the principle for the house is not unlike this simple example.

In developing the subject of the modern house, it may be well to discuss the trends in contemporary residential planning and to mention a few of the heating advancements which have made this planning concept possible. In the plans shown, a house of traditional precedent, in Figure 1, is contrasted with one in Figure 2, which is based on present-day thinking. In the former, it may be seen how the house was planned about the massive central chimney. Fireplaces in the various rooms were provided for heating, and rooms were separated one from another by doors creating spatial dams or cellular enclosures. Orientation to the sun or to a view was greatly limited and plans became very much stereotyped. Windows were small and positioned too often for symmetrical effect in facade, with seemingly little regard for interior con-

* Associate Professor of Architecture, The Pennsylvania State College.

siderations. An example of this is to be noted especially in the location of certain windows on the second floor.

The reason for the restricted use of glass is partially attributable to the fact that flat glass, free from

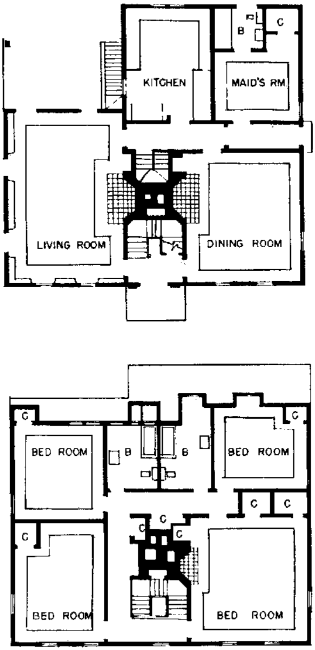


FIGURE 1

aberrations, was difficult if not impossible to produce in larger sizes and, therefore, it was necessary to divide the sash by muntins into small divisions. This not only reduced visibility and light transmission but also increased maintenance and cleaning difficulties. Overall sash sizes were kept small because of the knowledge, gained by experience, that comfort in winter was in the inverse ratio to window area. I believe that, paradoxically, window to wall proportions in the colonial house were established more by this heating consideration rather than by esthetic sensibilities as present-day copyists more wishfully like to believe.

In the second illustration showing the open or spread plan of a contemporary house, a complete release from traditional ties is apparent. Generous use is made of the window wall which achieves greater integration of interior and exterior space. Orientation to the south, and in this case to a view as well, is obtained for all the family rooms, including the kitchen. Interior spatial feeling is enhanced by omission of doors and separating partitions between rooms that require less privacy. Since fireplaces are no longer actually required with present heating equipment, they may be located, when specified, wherever convenience indicates.

Plate glass, which is now available in almost any size desired in the home, is not economically prohibitive. Double glass, factory sealed, makes the use of larger glass areas more feasible from the heating standpoint. With forced warm air heating, the use of cold air returns under the windows, either in the base or in the floor, provide for removal of air which has been cooled as it passes downward past the glass. This eliminates or greatly minimizes the possibility of discomfort from drafts. These and other building design improvements make possible greater exposure to the out-of-doors, a quality especially desirable in the less crowded suburban locations.

In the plan of Figure 2 the heating plant is located on a lower level, but perusal of magazines often reveals examples where the basement heater space is supplanted by a ground floor utility room. In these and in the open or spread plan, heating equipment which is not dependent upon gravity for circulation is employed. Fans or pumps force the heating medium to the desired location. Zoned heating, making possible controlled temperatures in various parts of the house, is also available.

It is evident, therefore, that planning concepts are undergoing radical changes, regardless of whether the architect in his urge for greater planning freedom stimulated improvements in heating systems or whether the engineer first provided better, more flexible heating equipment for the architect.

Advancements in building design, however, have not been confined alone to planning and heating equipment. Many new materials and accessories have been developed to provide greater comfort from the elements, and incorporation of these is becoming requisite for the home builder. Some of these materials, which are classified under the heading of heat sealers, are caulking, improved building papers, insulation in its various forms, factory sealed double glass, and storm sash. Weather stripping, now standard on better windows and doors, has reduced air leakage and at the same time has improved year-round window operation. In the spread plan especially, with its greater exposure of wall, windows, and roof, heating costs, which would have proved exorbitant without the use of the various heat sealers, have been kept within average budgetary limitations.

In spite of this apparent perfection, conditions have developed which require as careful consideration of structural details as the planning itself. Undoubtedly, problems of production, installation, and maintenance peculiar to the individual products were studied and presumably eliminated prior to sales promotion, but in their combined usage, some difficulties have arisen. Paint failures with former time-tested formulas have been experienced. Dampness and staining of wall paper and interior painted surfaces are not uncommon complaints. Water literally dripping from windows and frost visible on the under side of roof boards also give concern to many new home builders. As a consequence, research projects have been initiated in various university and government laboratories to ascertain the causes of these difficulties; and results of tests indicate that they are often due to the *condensation of moisture* from the air *within the house.*

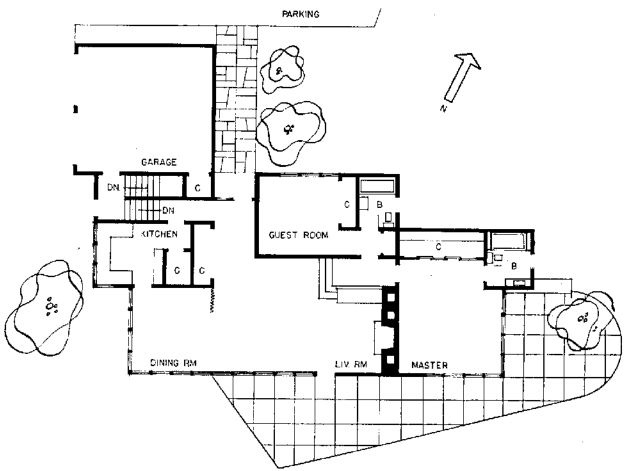


FIGURE 2

All present-day houses of both traditional and more modern concept which utilize the various heat sealers are susceptible to this condition. In older less tightly constructed houses, infiltration of cold outside air of low moisture content reduces interior relative humidities to lower percentages than are apt to exist in houses of recent construction. Water vapor is absorbed by the air from dampness in basement or crawl spaces, from bathing, cooking and other domestic uses of water. In certain types of heating systems, moisture is introduced into the air by induced evaporation in amounts of several gallons per day. Because of the use of heat sealing materials and methods, infiltration is greatly reduced, and humidity conditions may build up to a point where condensation occurs.

As is known from principles of physics, water vapor condenses on any surface which is at or below the dew point. A familiar example, in summer time, is the condensation of water vapor from the air on cold-water pipes. Likewise in winter, water or frost will appear on window glass when its temperature drops below the dew point of the interior air. In severe cases of interior condensation, water dripping to the window sill may be mopped up before damage is done, but the occurrence of this phenomenon in the wall or ceiling is not so readily apparent and a solution is somewhat more involved. Fortunately, however, most wall materials are less efficient conductors of heat and under average conditions, no difficulty is experienced.

In order to stress the need for maintenance of reasonable, maximum interior humidities, let us consider what has been found as a result of research and in actual instances where unfortunate condensation problems have been caused by the maintenance of too high humidity during periods of prolonged near-zero temperatures. Cold air penetrating through cracks in siding and sheathing will reduce the temperature of the inside plaster wall at various locations to the dew point, whereupon moisture condenses on the wall surface. It has also been established that inside air, because of its higher vapor pressure, migrates outwardly towards the colder air of lower pressure. If the temperature of either the siding or the sheathing reaches the dew point, then condensation will take place, raising the moisture content of the wood to the point where paint may peel or blister. Under severe circumstances, other materials such as wall or ceiling insulation are also susceptible to moisture difficulties.

Popular articles in various magazines and certain attractive advertising have sold the public on the advantages of higher humidities from the standpoint of health and comfort. Physiological tests which have been conducted seem to demonstrate that a 66° E.T. (effective temperature) produces optimum conditions of winter comfort for the average individual under average conditions of activity. This corresponds to a combination of 70°F and 50 per cent relative humidity. From the construction standpoint, such a condition with prolonged zero temperature would very likely produce moisture condensation problems in the structure. In this regard recommendations have been made by various manufacturers for their specific products. For instance, a chart published by the National Mineral Wool Association gives the "inside relative humidity that can be maintained for different inside air temperatures in combination with different outside air temperatures without excessive condensation within a frame wall insulated with 3⅝ inches Mineral Wool Insulation and no vapor barrier." The maximum relative humidity recommended for 70° inside temperature and 0° outside is 33 per cent. This temperature combination with a 50 per cent relative humidity which is the optimum for a 66° E. T. at 70° is an invitation to trouble. The seriousness of condensation in any part of the structure is obvious and, therefore, needs no further explanation.

Recommended solutions for eliminating the danger of condensation of water vapor resolve themselves into two types. The first and simplest is to maintain lower inside humidities, especially in extremely cold weather. This can be done by decreasing induced humidification and by the introduction of greater quantities of outside air.

The second type which is especially applicable for new houses constructed in the region above 40° latitude (corresponding roughly to a line through Salt Lake City, Denver, Kansas City, Cincinnati, and Washington), permits the maintenance of somewhat higher humidities. This is accomplished by the installation of *a vapor barrier between the heat sealing materials and the inside surfacing* of walls and ceiling to prevent migration of moisture. Such a barrier may be made of a moisture-proof paper or other vapor-resistant material. It should be fastened to the studding on the room side before the lath or interior surfacing is applied and it should extend from floor to ceiling without joints. Laps should be made only where adequate backup is provided.

Other important suggestions are offered by research organizations and government bureaus, but time does not permit of more detailed description of these methods. It should be noted, however, that application of a highly vapor resistant paper in the *usual location between siding and sheathing,* is in *exact contradiction* to scientific findings and (in the heat-sealed house) *is absolutely wrong if present knowledge is correct.* Since most postwar houses will probably be built without the services of engineers, architects, and contractors familiar with the moisture problem, it is highly essential that builders and home owners be made acquainted with this condition.

While utilization of cooling for the entire house does not seem imminent because of the cost, it may be stated that no condensation problem is anticipated because temperature differentials are small compared with winter conditions. Extraordinarily high summertime humidities, such as are encountered at times along the eastern seaboard, may make it advisable to lessen temperature differentials at times of near saturation conditions when cooling equipment is used.

It is an interesting closing observation that at extremely low temperatures in winter, when a higher inside relative humidity would produce optimum physical comfort, condensation dangers in the structure are most acute, while in summer, when the relative humidity outside is high and interior cooling would seem to be of greatest benefit, condensation dangers are also greatest.

DISCUSSION

C. C. Wright presiding

H. F. HEBLEY[1]: It is rather welcome to have an Associate Professor explain to the audience some of the developments in modern housing design. I want to mention something of interest regarding the coal industry in its attempt to acquaint various people on some of the problems of heating with solid fuel. The Bituminous Coal Institute offered a prize last year for the best design of a basement for a dwelling using solid fuel. I had an opportunity to see the drawings submitted in the competition. There were about 150 to 200. It was revealing to note that out of 150 to 200 designs only about 24 of them were practical. There is a great need for a conference of this nature where the architect, the designer, and the manufacturer of heating equipment may work together.

I think we have a great deal of prejudice to fight in that people who have been brought up in homes of the vintage of 45 or 50 years ago still think along old lines. Any innovation that is presented is received with scepticism.

One of the coal companies in Western Pennsylvania is building an office building, and is installing radiant heating. I am looking forward with a great deal of interest and trepidation about the way the installation is going to be viewed. It is going to be forced hot water and Mr. Hawk, who is also on this program, has had a great deal to do with the design of that particular installation. It has been adopted deliberately in order to break down prejudices and also to furnish the interested parties in the company with a new viewpoint on new developments in the heating field.

The basementless building that was shown on the slide should not be condemned because of no basement. I mean, we should look at it with an open mind and pay more attention to developments and be more susceptible to suggestions. However, I do feel that the various callings and enterprises that enter

[1] Director of Research, Pittsburgh Coal Company, Pittsburgh 30, Pa.

into constructing a home should all work together and not be altogether temperamental.

I recall a meeting when we were just trying to do what we are attempting here today. A coal man generally doesn't have his ideas together. He attends a meeting with little arranged. We were meeting with architects, and before we spoke the architects had anticipated us and we did not have a chance to say anything.

The question of the scenic window requires a comment. Before the double-sealed windows had reached perfection, the architect told us plainly that if we couldn't heat a building with such a window, it was the fault of the heating engineer's design. It was his building, yet our problem to heat it. If we could break down attitudes like this and work together, we would be more successful in bringing out better designs.

S. J. LEVINE[2]: I want to say first that Professor Heidrich has presented a very interesting and challenging paper. I have jotted down a number of items that present problems and challenges to the designers of heating equipment to be used with these new houses.

The first of these items is insulation. Using insulation cuts the heat loss of a house of given mass and volume and, therefore, requires a smaller rating of heating unit. However, proper allowance must be made for the fact that house volume and house mass have not changed.

Newer houses have tighter construction and, therefore, particular care must be taken to insure sufficient combustion air for heating equipment.

Professor Heidrich touched extensively on the matter of humidification. As designers of heating equipment we shall have not only to provide adequate humidifiers but also suitable controls.

The new housing presents problems in unit configuration. By that I mean the design and shape of the house may often control the shape or the configuration of the heating unit. Will there be a basement, should the heating unit be suitable for utility room installation, will it hang from the ceiling, etc.?

As the new houses provide improved livability for their owners, so should the owners expect to obtain improved heating comfort in quieter units and in closer temperature regulation. These are problems of the heating equipment designer in large measure.

W. CLAY[3]: I am very glad Mr. Heidrich has brought up the question of humidity, because it is one of the subjects needing more study than has been given to it. All the materials manufacturers recognize this. They have formed an informal Council on Humidity and Condensation Control which includes paint manufacturers, the millwork manufacturers, insulation manufacturers, and heating and humidity equipment manufacturers, and others.

You spoke about controls. Control of humidity is essential as the house gets tighter from standpoint of infiltration. I know of no better way of preventing condensation on the inside surface than by keeping the temperature of the inside surface of the wall above the dew point, which is most likely to be accomplished by insulation.

The question of humidity in a house, as far as comfort, economy, and health requirements are concerned, needs a great deal more study than it has had. We have based the recommendation of a maximum of 40 per cent relative humidity largely upon the statements of Dr. Yaglou of Harvard Medical College who says that relative humidities in winter time of over 40 per cent are not desirable for health, except in infant wards in hospitals. The question of higher relative humidities has, as a medical advantage, been a debate among doctors. However, Dr. Yaglou has determined in his mind from observation and experiment that relative humidities over 40 per cent are not advisable.

A study has been made of the cost of humidification. It costs as much to evaporate water as it does to heat a house to get the same point in the psychometric comfort chart.

I do want to come back to one point. That is, control of humidity. Humidification is a great thing, a great invention, but uncontrolled humidity is a bad thing. The question of bringing cold air or outside

2 Heating Equipment Engineering Division, Air Conditioning Department, General Electric Company, Bloomfield, N. J.

3 Secretary, National Mineral Wool Association, New York 20, N. Y.

air into the house for combustion purposes has advantages. The introduction of air of low moisture content into the house and mixing it with high content air developed from bathing, etc., will reduce humidity automatically.

I don't feel I should comment now or later in regard to basements. The question of the no-basement house is very attractive to the architect. It is not very attractive to the man who wishes to store storm sash, etc. There are many other things about the basementless house that are very bad. Because of the cost of construction, houses are being reduced in size and the need, therefore, for storage space is greater and greater. Any wife will tell you that she doesn't like to throw away things, and I don't like my things thrown away. If there isn't any basement, there is little storage space. That is a minor observation but it is important in household economics. The crawlway space is unfortunate as a design, and has probably only been introduced as first cost economy in low-cost houses.

It is costly to insulate but it is uncomfortable not to insulate. Probably the most promising method of handling no-basement houses is the "basement" on the ground floor with some provision for radiant heating in the floor.

DISCUSSER FROM FLOOR: One thing to bring up here is the question of ventilation for the cooking odors, etc. As we insulate houses, put in double glass, solid windows, storm sash, etc., we stop the infiltration of air that has helped in the past. This has become a problem.

DISCUSSER FROM FLOOR: I failed to say that the basementless house is not popular. The recent Curtis publications survey of the desires of the public for various features in houses showed that 76 per cent of the people who spoke about basements as a feature of houses which they wished to have did not want basementless houses.

DISCUSSER FROM FLOOR: No one has said anything about the use of chemicals for control of humidity. Is that impractical?

K. J. HEIDRICH: I know of some people who are trying to keep their basements somewhat dry in the summer by the use of calcium chloride. The problem of actually controlling humidity by the use of chemicals is adding another kind of equipment in the house which is probably already too equipmentized.

There was a part of the paper which I wasn't able to cover. Dissemination of news should be made in popular magazines to advise people of the difficulties of condensation, and especially the problem brought up by using paper of highly vapor-proof quality on the outside instead of inside wall. That is very important if we are going to allow people to use induced evaporation in quantities beyond which the structure can withstand.

What Builders Are Doing to Meet the Public Demand for Better Housing[1]

By Frank W. Cortright[2]

V-J Day caught this country with its reconversion plans down. One member of President Truman's cabinet frankly admitted that his agency, one of the most important of our wartime bureaus, had given no thought whatsoever to a change of pace for the peacetime operation. Producers of building materials and the home building industry generally were unprepared to quickly convert from a war to a peacetime job.

There is an unprecedented demand for new housing at this time. Minimum estimates of families doubled up and new families created exceed three million. That these are in large part veterans' families increases the seriousness and importance of the situation. The men and women who have fought this war are certainly entitled to a decent home upon their discharge from the service, but in nearly all urban areas they will not find such homes available for a while at least.

It is timely, therefore, to consider the factors which, in their combination, prevent a large volume of new residential construction in the near future.

(1) *Producers of the components of construction are currently faced with extremely serious problems of wage adjustments and OPA price controls.*

Heading the list of critical materials are lumber, brick, cast iron pipe and gypsum products. Generally speaking, these industries operate upon wage levels somewhat less than many other industries and substantially less than that of war plants and shipyards. The work is hard and the war worker or returning veteran is naturally loath to accept this type of employment at the wages offered.

In addition, each of these industries has other problems such as repair or replacement of worn-out equipment, inability to secure certain raw materials, and a tax situation which discourages further profits this year. It is only as these matters are adjusted that the necessary components of construction will be produced and flow out through the pipelines of supply.

(2) *Home builders have serious labor problems.*

Skilled mechanics in the building trades are simply not available in some parts of the country. Apprentice training has been lacking for many years in certain of the trades. Many construction workers have gone into war work during the war years and have come back reluctantly to the more arduous work of home building. Nevertheless, it seems reasonable to assume that this is only a temporary condition, because the armed services have trained many men, and vocational schools have been started by both government and labor organizations. With the discharge of some 10 million men from the Army and Navy, this shortage should soon be made up, and, of equal importance, the productivity of labor should be increased at least 25 per cent above the present level. Herein lies one of our primary hopes for improved economy of operation.

(3) *Government control and competition provide a serious deterrent to residential construction.*

Although on October 15, 1945, wartime restrictions were lifted from all construction, OPA Administrator Bowles, supported by other government officials, has

[1] Presented by W. B. Dixon, Jr., Director, National Association of Home Builders of the United States, 317 Castle Shannon Blvd., Pittsburgh, Pa.

[2] Executive Vice President, National Association of Home Builders of the United States, Washington, D. C.

been urging Congressional authorization to place upon new construction a totally unworkable pricing formula. Faced with the difficulties of clearing tentative rent schedules, and with the possibility of government fixing of sale prices upon new construction when completed, the industry is hesitant to move into its maximum operation. The Wagner-Ellender Bill suggests an initial program of public housing in the amount of 500,000 units, which, of course, is only a modest start. By its very nature government ownership and operation of subsidized housing sterilizes private enterprise and operation in any but the higher priced field. The experiment in socialized housing under the U. S. Housing Act has clearly proved that if extended in the postwar period, it will eventually destroy private building as it has done in a number of European countries.

THE LONG-RANGE OUTLOOK

(1) *Employment Provided*

Assuming that most of the current problems will be solved in the next year, we can look ahead to the most productive decade in the history of residential construction. An unprecedented demand supported by unprecendented savings, earmarked for housing, gives promise of a 10 million home market. Our National Association has set a goal of 500,000 new starts in 1946, 750,000 in 1947 and a million annually, the succeeding five or ten years.

Approximately one worker on site is employed annually for each house built. In 1925, 939,000 units were constructed and 989,000 men employed. During the depression year of 1934, 109,000 men were employed to build 90,000 units. It has been estimated that one and one-half workers off site are employed for each man on site. Therefore, the production of a million homes annually would provide direct employment for two and one-half million workers on and off site, plus an undetermined number who would be employed indirectly in the construction of roads, schools, shopping centers, and the innumerable items of home furnishings and appliances.

(2) *Financing Methods*

One of the most encouraging factors in the postwar market is the availability of almost unlimited funds for mortgage financing. Not only are savings banks, building and loan associations, and insurance companies bursting at the seams with funds seeking this outlet, but also the Federal Housing Administration is moving into a vastly expanded operation. The new Commissioner, Raymond M. Foley, has approved a revised Section 207 procedure by which large rental housing projects will be financed. They have established a new classification known as "country homes" by which they can insure mortagages on properties beyond the suburban areas of cities which in the past have been ineligible due to the lack of roads and utilities. Of very great importance is the new policy of making firm commitments to builders for loans up to $10,000. Although this FHA procedure is conservative (80 per cent up to $6000 and 60 per cent between $6000 and $10,000), it will encourage really large-scale operations by operative builders with a resultant lowering of cost of the individual home.

(3) *New Construction Techniques and Materials*

During the war years the builders of the nation accomplished great economies through precutting, site fabrication and the use of sub-assemblies. Builders who had never constructed more than a score of homes a year moved into single projects of 100, 500, and 1000 individual houses. In spite of constant increases in labor and material costs, this housing was produced at a remarkably low figure through quantity purchasing and modern streamlined methods. In addition to these improved methods of construction, it is hoped that prefabrication may make available floor, wall, and roof sections at an economical figure. Although prefabricated housing as such will probably not reach more than five per cent or at the most ten per cent of the market in the early postwar years, it certainly should provide conventional construction with subassemblies and panels. Moreover, the U. S. Steel Corporation, the Fritz Burns-Henry Kaiser Community homes, the Ingersoll Borg-Warner Corporation, and others may provide the industry with mechanical cores and panels upon an attractive basis.

(4) *Better Housing at Lower Cost*

Better housing at constantly lower cost for all income groups is the primary objective of our National Association. In contrast with automobiles and most durable consumer goods, housing is produced by many thousands of small businessmen operating as individuals in every part of the country. They are dependent upon securing land at reasonable figures, employing labor upon a satisfactory basis, and arranging financing which permits them to keep their modest capital fairly liquid; they are also concerned with conforming to building codes, zoning restrictions, and other local requirements.

By its very nature a house requires the services of more than a score of building trades and requires some several hundred different kinds of materials and items of equipment. Furthermore, climatic conditions and community tastes vary greatly. Because of this, and the constantly rising cost of both materials and labor, the home building industry cannot enter into mass production with all of its advantages of central purchasing and streamlined operation. However, great progress has been made in recent years, and you may be sure that the industry will produce a better, more attractive, and more efficient product in the postwar years ahead.

(5) *What Does the Home Builder Require of the Heating Industry?*

This question is easily answered. The home builder wants the heating industry to make available the kind of heating equipment that the public wants at a price the public can afford to pay. In a recent survey conducted by Crossley, Inc. for *Architectural Forum,* it is interesting to note that, of the many families questioned, 35 per cent expressed a desire for "good heating systems"; 34 per cent, modern, well-equipped kitchens; 26 per cent, modern bathrooms and 25 per cent, plenty of closet space.

The Curtis Publishing Company survey disclosed that warm air heat is preferred by 38.4 per cent; hot water, by 30.8 per cent; and steam, by 19.9 per cent. Besides, 35.1 per cent wanted a gas furnace; 29.5 per cent, an oil furnace; 23.8 per cent, a coal furnace; 3.9 per cent, an electric furnace; and 3.1 per cent, a space heater. For water heating purposes, a gas heater is the outstanding choice of these prospective home owners, of whom 53.8 per cent prefer this type, while 22.7 per cent prefer an electric water heater. In addition, our own surveys have indicated that the public hopes to have both winter and summer air conditioning. There is probably no other single factor which could do so much to insure the sale of new housing as air conditioning. Insulation has, of course, become a must for new home construction.

The National Association of Home Builders will hold its annual exposition and convention in February 1946 at the Hotel Stevens in Chicago. Each year at this time, we invite the country's largest manufacturers and industrial groups to present to the home builder those products, materials, and services which will be available to the industry in the ensuing year. The conference program consists of panel discussions on new materials, financing, sales, and new construction techniques. Careful analysis of the panel held last year, at which time the subject of heating was discussed by industry's representatives, has revealed: (1) assurances of new high standards of convenience, efficiency, and healthfulness, (2) emphasis on automatic heating and (3) fuel economy as a primary objective of manufacturers of heating equipment. It was stated that of the prospective home owners questioned, 90 per cent wished automatic heating for their postwar homes. The industry awaits with interest further developments in radiant heating, baseboard heating, modular control, and all other improvements in matters of health and comfort in the field of house heating.

CONCLUSION

We and you have a great responsibility in postwar housing. It is most certainly your responsibility to provide us with the most efficient and generally satisfactory type of heating equipment possible at a price the public can afford to pay. It is our responsibility to convince the public that it is better business to pay more for really good, economically operated equipment, and to induce the public, insofar as possible, to buy the best, which, in the long run, is always the cheapest. By working together we can measure up to our full responsibility in providing employment and vitally necessary housing in this great postwar period which lies immediately ahead.

DISCUSSION

C. C. Wright presiding

E. L. WHITAKER[1]: I am an Associate Professor of Architecture and I also represent the Central Pennsylvania Chapter of The American Institute of Architects.

I think Mr. Richmond summed up very well the picture of dynamics of heating equipment and Mr. Dixon has very ably covered the field of the housing expert, as represented by the work of the National Association of Home Builders. One other speaker from the floor mentioned the need of cooperation between the various parts of this picture, because it isn't just heating engineers, not just housing people, it is the combined efforts of everybody that are important in solving the problems ahead of us.

Mr. Hebley mentioned that in the past there had not been good cooperation between architects and fuel people or the heating engineers. I might go on record as saying that the Central Pennsylvania Chapter of the A.I.A. is actively cooperating with the Builders' Exchange in Harrisburg, that is the unit closest to our organization in Harrisburg. We have had several meetings and are trying to get on a cooperative basis with builders.

I might say that in the past the architect has often been remiss in cooperating with the heating and building industry. I would like to ask Mr. Dixon, what he could suggest would bring about better relations between the architectural profession and the building industry? I think whatever he says would apply to better relations between the architectural profession and heating industry.

W. B. DIXON, JR.: Along that line, I would like to mention that just two weeks ago there was a meeting of the directors of the National Association of Home Builders. Our committee met with a committee appointed by the A.I.A. to discuss recommendations made to architects which had been approved by our board prior to the meeting. Members of the A.I.A. committee reacted favorably to these proposals, but were unable to make definite commitments until approved by the A.I.A. Board of Directors.

Private builders have definite thoughts relative to architects in the home building field. In low cost housing, an architectural fee of 6 per cent for plans, specifications, and supervision would exceed the net profit of the contractor who carried all the risk. We work on a contract basis. We are trying to set up a plan with the architect whereby he turns out all work on an hourly basis. That is one way of working it.

I believe the main thought to be brought forward in the whole industry is organization and cooperation; the building industry has been reluctant to get together, to form a workable group and to talk over mutual problems. Instead of going out in separate groups, designers, heat men, architects, contractors, supply men and others should associate with different groups of men in the industry and talk over problems with them.

I know, as a builder, I appreciate any heat man coming to me if he has new ideas or thoughts. I will gamble on anything so long as it is possible. I will try it. I will go out and build houses as experiments to try systems and ideas. If an architect has an idea, I'll try it! These things must be done to get public reaction. You can't write it in papers and print pretty pictures. The public must see actual things.

I have been trying to get radiant heat started. I'm sold on it. It seems the Fire Underwriters have found difficulties with radiant heating in Detroit after it has been used for six years. This is an example of the six-months-too-late idea previously mentioned by Mr. Richmond. The entire building industry should be bound together with a small, representative group that could study out its problems.

E. R. KAISER[2]: The papers and discussions at this conference have been based largely

[1] Associate Professor of Architecture, The Pennsylvania State College.

on the heating of houses with individual heating plants; yet, fully automatic heating is deemed essential by many home owners, and is a hope of all householders.

Bituminous Coal Research, Inc., has been sponsoring a study at Battelle Memorial Institute, Columbus, Ohio, to determine the economics of heating groups of residences from small heating plants that generate steam and distribute the steam to the individual houses by underground piping. The results have not been published because the study is still in progress, but information at hand indicates that groups of houses built substantially at the same time can be provided with district heating at a cost not in excess of heating with natural gas or oil. The district plants would be fired with coal.

The additional cost of underground piping is partially offset by the savings due to the elimination of chimneys, individual furnaces, coal bins, ash containers, and the like at each house. A simple heat exchanger and a condensate meter are all the equipment needed in each house. Industrial steam coal, which is comparatively low in price, can be used by the heating plants. The customers would be billed monthly.

To make the group heating economical it is necessary for at least 40 houses to be heated from a single plant. Depending upon the comparative costs of fuels, it may be necessary to have 80 or 120 houses connected to one heating plant before the cost of the group plan is competitive.

Builders and developers should consider district heating because it is a fully established method in downtown areas of cities, and it has been used successfully in residential heating in a number of cities. A publication will be released as soon as the information is complete.

[2] Assistant Director of Research, Bituminous Coal Research, Inc., Pittsburgh, Pa.

K. C. RICHMOND[3]: Mr. Dixon, on the average, how much do you pay for the heating facilities in the average home you build?

W. B. DIXON, JR.: In what price-class home? The cost of heating facilities will depend upon the allowance made in the cost estimate of the home. Builders, today, are sitting down and figuring things out, allotting a certain percentage of the cost to heating requirements. For example, on a $10,000 home in Western Pennsylvania, $500 may be allotted for a complete heating system. I can show you actual costs of homes built for $8,500 to $12,000 in 1939, 1940 and 1941 in which a complete unit—a gas-fired, forced air conditioned unit, built by a well-known manufacturer, the duct work and installation was placed for $350.

K. C. RICHMOND: What would coal-fired equipment cost in Pittsburgh?

W. B. DIXON, JR.: A little less. As far as duct work and so forth, it is the same. There will be additional cost for fuel storage space, whereas the furnace price may be 30 per cent less than that for a gas furnace. The cost would be higher with a stoker unit unless the stoker people market models selling at a lower price than present units.

[3] Editor, *Coal-Heat Magazine*, Chicago, Ill.

Proper Basement Design and Its Economic Advantages

By E. L. Whitaker, A.I.A.*

AT THE present date, 1945, a definite cycle of basement planning appears to have been completed. The cycle started in the earliest Colonial days, when the first houses were basementless. The floor was packed earth and heat was provided by a clay or mud packed chimney. Gradually, as time and materials became available, a basement was a much needed part of the house. It was used for winter storage of food, wine, meat curing, and a place to age the cider.

Heating stoves appeared in the 1850's, but central heating didn't come into its own until the era following the Civil War. Then the heater was first a gargantuan affair, with a complex octupus arrangement of ducts and pipes; finally it was a large cumbersome steam or hot-water system. Since all the systems operated by gravity and mechanical equipment as we know it today—pumps, circulators, and fans—were nonexistent, the heating plant was of necessity in the basement.

From 1920-1945 the basement underwent a complete change. Automatic heating equipment was developed. Heaters were improved and packaged in smaller, more efficient units.

Although basement space was now available for an increased number of activities and uses, planning for efficiency was at best only a makeshift arrangement. The basement was still a dark, incongruous collection of household storage, heater, fuel storage, and laundry and in many instances left over space became the "rumpus room" so called. Frequently, the heating plant and fuel storage came as a complete afterthought and was fitted into whatever space was available. Heating, although automatic, was not efficient in such a hodge-podge arrangement, and the basement was definitely *not* integrated *space for living.*

Out of the dark war years we are emerging with a new philosophy of home planning, and space arrangement based on improved automatic heating, new labor saving devices, an improved use of materials, new materials, and the all-important fact that few housewives have servants, and, consequently, must do all their own work. In the minds of many 1945 architects the basement plays a very minor role or is completely eliminated.

With the thought of efficiency and step saving, the architects are urging the home builder to bring the laundry, the heating plant, and storage above ground. Laundry equipment, now compact and automatic, and the heating plant, also compact and automatic and using compact fuels, are placed in a clean, well-lighted utility room near or as a part of the kitchen work area. Automatic heating plants using solid fuels needing storage space are placed in a partial basement. Houses built with no basement or a partial basement have created real problems in ventilation, insulation, and severe heat losses through the floors. According to the National Housing Administration, the problem has never been solved adequately—i.e., how to insulate and ventilate crawl spaces in a partially excavated basement. The 1945 architect solves all these problems in one clean sweep—radiant heating. Radiant heating, a system revived from Roman days, solves the problem by placing the house on a slab poured directly on grade. Embedded in the slab is a system of pipes through which hot water or steam is circulated. In some instances warm air has also been used. The floor now becomes the heating surface. Apparently, the need for a basement, except for storage, and space for a heating system using solid fuels, has vanished, and *the cycle has been completed.*

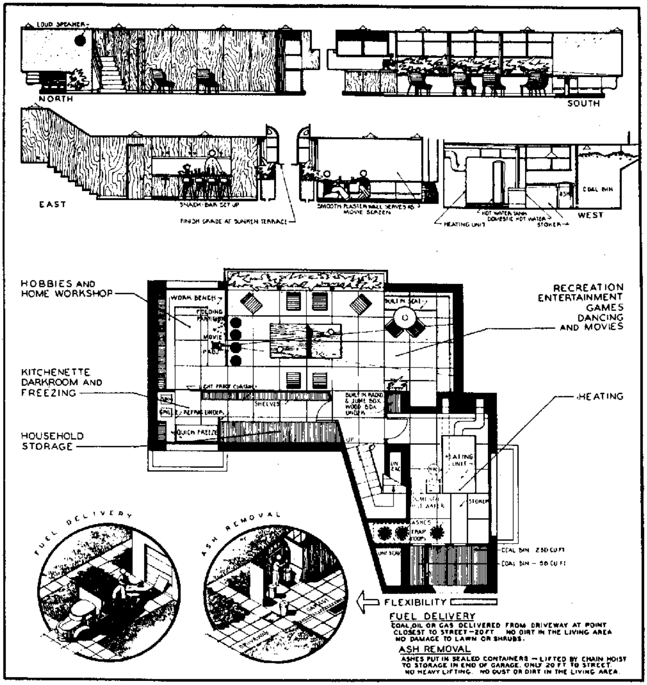
At this point, it would be well to examine the

* Associate Professor of Architecture, The Pennsylvania State College.

whole question of basements in the light of 1945 postwar thinking, but from an entirely different angle, namely, *cost!* 1945 building costs are up 30 per cent to 53 per cent over what they were in 1940. All indications are that prices will never again go back to 1940 or prewar levels. In terms of a $6000 house in 1940, it means $7800 to $9000 for the same house today. In terms of actual living space within the house, it means less space for the money; a more intensive use of the space we can now afford, or the re-evaluation of space not now considered; namely, basement space.

The basement is one part of the house in which added usable space can be created for little extra cost. Under ordinary soil conditions, it is less expensive to excavate a full basement with power equipment than it is to hand dig or scrape trenches for a partial basement or unexcavated house. Best construction practices require foundations deep enough to avoid detrimental effects of frost. This is true regardless of whether we do or do not have a basement. In northern states this means the foundation for a house without a basement must usually be carried about half as deep as for one with a basement. If ordinary soil conditions exist, basement space can be created for *less cost* than similar *space above ground.* However, the basement space thus provided should be planned with the same care and consideration that is given to all other parts of the well-planned modern house.

The first and most important considerations of proper basement design are determination of soil and underground water conditions. Under ordinary soil conditions, excavation, footings, and walls offer no serious problems. However, adequate precautions must be taken to insure that the basement will be dry at all times. Damp-proofing, or even water-proofing and tile drains should be considered at the time the basement is built. If a basement is damp or wet, money and remedies are at best only ameliorative after a house is built, and all the careful thought and planning of space arrangement will be lost. Good damp-proofing, water-proofing, and even mildew preventative applications are readily available.



Good natural and artificial light and ventilation are other necessary preliminary considerations. A serious fault of basements in the past has been the closed-in feeling, due in a great measure to inadequate lighting. Adequate light and ventilation cannot be obtained from tiny basement windows set in a small areaway below grade. If areaways are used, they should be carefully designed to produce a maximum of daylight and sunlight. One method for obtaining a maximum of daylight and sunlight is by excavating for a sunken garden or terrace at the same time the basement is excavated. The sunken garden or terrace can then be enjoyed from the basement or the first floor.

Good ventilation is possible from basement windows, but during the cold fall, winter, and spring months other artificial ventilation is important. A small, electrically operated fan built into a flue when the chimney is erected will serve for cold weather ventilation.

Another problem, to date not adequately solved, is that of condensation in basements during the summer months. Certainly, more information and research are needed to remedy this problem.

A dry, well-lighted, and well-ventilated basement being assured, the next consideration is the *choice* of *heat* and *fuel*. Whatever the choice of heat—forced warm air, circulated hot water, steam or radiant heat, all systems require a certain amount of ducts, pipes, valves, etc. Careful planning can assure that the feed lines and returns will be so arranged that they do not interfere with usable space in the basement. The choice of fuel, however, is another problem. We are told that more residences are heated by coal than by any other fuel. Further, we are warned that the known coal reserves are adequate for the next 3000 years, whereas other fuel supplies are dwindling to a point where their use for home heating might be prohibitive in cost. There is no serious problem involved in arrangement of storage for fuels such as oil and gas, but there is a very definite challenge to the designer to provide adequate, efficient storage for coal.

The location of the heater and fuel storage should receive first consideration in the over-all basement plan. Regardless of the choice of heat and fuel, the heater or furnace room should be a separate room, dust proof, well lighted and ventilated, and separated from the remainder of the basement and the main body of the house for reasons of dust, dirt, and noise.

DISCUSSION

R. M. Gerhardt presiding

H. F. HEBLEY[1]: I am afraid I criticized basement design this morning. I agree with Mr. Whitaker that if you have three types of fuel—solid, liquid, and gaseous; this is the order of difficulty in which they are handled—solid, hardest, and gas easiest to handle. This brings up the question of the economics and mineral resources of the country. He mentioned that there is a 3000-year supply of coal; that has been based on estimates. But in our recent war, our resources were heavily drawn upon.

Gas is being piped and handled beautifully from the engineering point of view, but you do have the problem of space heating running only eight months a year in these latitudes. The gas industry is showing great ingenuity in trying to balance the load.

Previously, I mentioned the fact that some designs of homes and basements were utterly impractical. One example, the comfort heating competition was set up for the use of solid fuel, and in one place the opening into the coal bin was placed in the floor of the garage. If a person wished to bring in coal and it came into the garage drive, one had to remove one's car out of the road and then back the truck in. Most trucks are of the elevating type so you can chute the coal. The

[1] Director of Research, Pittsburgh Coal Company, Pittsburgh, Pa.

clearance between the top of the garage and the top of the truck when elevated is far less than four feet. You could not use this method of unloading. It had to be shoveled in.

The other design placed the coal supply in the coal bin at the rear of the house. One had to drive through the garage, opening two doors to do so, and then dump the fuel. In another plan the architect was trying to keep the dust sealed away from the basement. He made the space for the coal bin about 8 to 10 feet deep. The only access to the bin was through the 32-inch diameter coal opening with no ladder to get down; you had to drop through the manhole and then whistle for someone to help you out.

R. C. JOHNSON[2]: Mr. Whitaker spoke of the necessity of raking the Anthracite over the worm. There is one way in which this can be overcome. This is the construction of the bottom of the bin being such that all Anthracite will flow to the end of the worm. Anthracite Industries, Inc. has worked out designs on coal bins of various types which make this possible. However, some prefer to allow the Anthracite to collect at the corners and when the Anthracite becomes low over the worm, they order a new supply. In the first place, it does not cost as much to store Anthracite in the corners as it does to construct a sloping bottom. In the second place, this always serves as a reserve supply in case fuel is not available.

With regard to the ash conveyor, we recognize that ashes should be taken outside the basement and we have been working on this problem for a number of years. Every solution that we have found has been very complicated and costly. We are continuing our efforts in this direction, and if anyone knows of a good practical solution, we would be very glad to consider it. We must admit that the problem of domestic ash conveying is a very difficult one.

[2] Vice-President, The Anthracite Industries, Inc., Laboratories, Primos, Pa.

Coal, Ash, and Clinker Storage

By Carroll F. Hardy*

EVERY HOME, regardless of the fuel which is to be used at present, should have an adequate coal bin or the basement should be so arranged that a coal bin can be readily installed. The experience of many thousands of home owners who have of necessity changed from natural gas or fuel oil to coal, proves the wisdom of this slight additional planning in designing the home.

Although coal forms the largest bulk of material ordinarily handled in the modern home, adequate provisions for handling and storing coal have usually been overlooked in designing homes in the past. The savings of the prospective occupant of a home in time, labor, and expense of getting coal into the bin and thence into the firebox of the furnace or boiler, certainly warrants the small amount of attention necessary to insure ease in these essential functions.

The rules are simple:

1. The coal bin should be located so that the coal can be moved from the coal truck into the bin without having to be rehandled.

2. The bin should hold a minimum of five tons and at least one-half a season's supply of coal.

3. All bins for coal which must be shoveled into the stoker hopper or fired by hand in the furnace, should be sloped towards the coal outlet door, and this door should be so located that a minimum of effort in firing is required.

4. The bin should be dust-tight regardless of the material used for its construction.

5. The distance from the bin to the heating apparatus should be in multiples of 3 feet to facilitate the location of a bin-feed stoker.

* Chief Engineer, Appalachian Coals, Inc., Transportation Building, Cincinnati, Ohio.

LOCATION

The coal bin must be located so that it is readily accessible to the private drive of the home owner, or, in some cases, to the alley or street. Then, regardless of whether the home has a basement or is basementless, coal can be delivered from a truck quickly and easily provided the coal-delivery window is located so that the truck can be coupled to it by means of a power-driven conveyor. The coal bin can be under the drive or inside the basement proper, or partly in and partly out. If under the drive, one or more manholes may be installed which can be protected from surface water by raising them off the surface of the drive (in between the automobile tracks) and the coal may be dumped directly into the bin. If located inside the basement, which in many ways is the most practical location, an elaborate coal chute and window can be installed, or merely an ordinary basement window provided. Here again the motorized conveyor can be extended from the coal truck through the window to the center of the coal bin and the coal placed without rehandling.

If the bin is properly placed in reference to the drive, it does not matter under which room of the house the coal bin is located, as present-day practices insure practically dustless delivery at all times. However, the heating plant must be located near the coal bin. With modern, forced warm air, forced circulation hot water, steam, or vapor, the heating plant may be installed in any part of the basement, or in a utility room in a basementless house. With gravity warm air, on the other hand, which is still the most popular and in some respects the most economical means of heating modern houses, the heating plant must be located near the center of the floor plan, which is ordinarily near the center of the basement. It can, however, always be located a few feet off center in order to have it near the coal bin. New houses should be equipped with bin-feed stokers for greatest convenience, and in this case the furnace should be located in multiples of three feet from the edge of the coal bin to facilitate using standard lengths of conveyor worm.

Another factor that influences the location of the furnace and coal bins is the location of the chimney. Architects usually locate the chimney to give the most pleasing appearance, balance, and contour. As the smoke-pipe should not be more than 10 feet long and because it should have as few turns as possible, the chimney, heating apparatus, and coal bin should be close together.

The average coal truck is about nine feet high, and when it is raised to allow the coal to flow out, it becomes about 12 or 15 feet high. Obviously, it cannot be raised and dumped inside the average garage or under any sort of a portico, if such things are still hung onto houses. The average coal truck needs plenty of the wide open spaces. The coal manhole or window should not be in the back of the garage or where it cannot readily be reached from outdoors by a conveyor 10 or 12 feet long.

SIZE OF BIN

Once the general location of the bin is determined, the next point is its size, or capacity. The average truck used for domestic coal delivery will hold about five tons of coal which will occupy about 200 cubic feet of space. To reduce the number of deliveries, with their attendant fuss, the minimum size bin should hold five tons of coal or more. A bin six feet square in a basement of average depth will hold enough coal to permit a five-ton delivery when approximately a ton of coal remains in the bin. If a larger sized bin can be installed, for example, one eight feet square will hold nearly nine tons of coal, so much the better. Too many of our present-day bins are long and narrow and thus are difficult to fill or to empty. Since additional help is necessary to store coal in a bin of this type, these bins are impractical. Round bins, which usually are made of metal, as well as rectangularly shaped metal bins or hyperbolically shaped bins, can be used. The decorative effect of these odd-shaped bins is considerably less than the square or rectangular bins which blend into the basement walls much better. The bin, of course, should reach the basement ceiling and be sealed against any possible dust seeping through it while coal is being delivered.

TO SLOPE OR NOT TO SLOPE

There are definitely two schools of thought on the question of sloping the coal-bin floor. If the design contemplates a hand-fired heating plant or a hopper-type stoker, the coal-bin floor should be sloped towards the outlet door. If, as all modern houses should be, the house is to be equipped with a bin-feed stoker which picks the coal up out of the center of the coal bin and delivers it to the heating appliance automatically, the coal will feed down at a 45-degree angle and thus leave a reserve of coal in the bin. This reserve, in case someone forgets to order coal on time, will come in handy. Concrete cannot be burned in a stoker, and a bin nicely sloped towards the stoker worm is of little consolation to the man who forgets to order coal. With the bin-feed stoker the consumer, unless he just likes the looks of coal, rarely looks into his bin, and, therefore, he is much less likely to notice that his coal is reaching the vanishing point.

If sloped, the coal bin should be sloped at a 45-degree angle, and by far the most satisfactory way of doing this is to use concrete paving over an earth fill. Sloping floors can of course be made of a reinforced concrete slab, thus providing additional storage space; or of tongue and groove lumber, with joints in the boards parallel to the flow of the coal; or of lumber covered with metal. Either one of the two forms of concrete seems to be the best means of sloping, if sloping is desired.

MATERIAL FOR THE BIN

Probably the most satisfactory way of building a coal bin in a new home is to cast it of concrete when the rest of the foundation is placed. Concrete or cinder blocks can be used to make a coal bin, particularly if the coal bin is an afterthought in this particular home. If wood is used, the studding should be anchored to the ceiling joists and to the floor. The inside of the bin should be lined with tongue and groove lumber, 1 in. by 6 in., or 1 in. by 4 in., or shiplap may be used. It has been suggested that if shiplap is used, particularly the present type which may warp after installing, a liner of building paper should be placed between the studding and the shiplap. The outside of such a coal bin should be lathed and plastered so that it will blend harmoniously with the rest of the basement. It can have a very attractive appearance under these conditions, and should last as long as the home, as there is not likely to be sufficient moisture in the coal to cause the wood to rot out. The danger of fire from spontaneous combustion of coal in the ordinary domestic coal bin is practically non-existent.

COAL-BIN DOORS

If the plant is to be hand-fired, or a hopper-type stoker is to be used, an opening for shoveling coal should be at the bottom of the bin, readily accessible so that the coal may be shoveled off the floor. For appearance, a standard door and casing should be installed on the outside of the bin with crossboards to hold the coal inside the door. Using a shovel box, there is little reason for taking these crossboards off, but they may be installed in slots or hinged to facilitate removal if desired. The coal-bin opening should be reasonably close to the hand-fired plant or the stoker hopper, and it is better to have it in the middle of one side of the bin, rather than at a corner.

In the case of the bin-feed stoker, the door should be placed immediately above the worm outlet, regardless of whether the worm comes out over the floor or is buried under the floor. It is not absolutely necessary to have a door in this case as it is so seldom necessary to enter a coal bin when a bin-feed stoker is used that the coal window or manhole could be used for this purpose. Inspection ports, at intervals of one foot in the bin wall, may be put immediately above the worm. Although these make it easier to determine the amount of coal remaining in the bin, they are not absolutely necessary. A well-guarded electric light may also be installed in the top of the bin if there is not enough natural light from the coal window.

PIPING AND DRAINAGE

Drains are unnecessary in a coal bin, providing the foundation walls are tight and surface water cannot get into the bin. Notwithstanding that some coal bins have incorporated a shower head, or other means of spraying coal, this is unnecessary for modern dust-treated coal.

While spontaneous combustion is extremely unlikely in the relatively small amount of coal found in the average coal bin, it is desirable, nevertheless, to keep all steam and hot-water lines, as well as smoke pipes and warm-air leader pipes, out of the coal bin. For not only will the flow of coal be obstructed by these pipes, but also the pipes may be damaged in the delivery of the coal. Moreover, there is always a possibility that under the right conditions, the heat from one of these sources might cause the coal to ignite.

The base of the chimney should not be in the coal bin, nor should a clean-out from an upstairs fireplace be located there. Aside from the remote fire hazard in these cases, it would be hard to remove the ashes properly from either the base of the chimney or the fireplace clean-out.

ASH HANDLING

Provisions for ash handling depend primarily on the period over which ashes are accumulated. Obviously, if ashes are to be accumulated over a six months' period or the entire heating season, it is necessary to make more provision for their storage than would be the case if they are collected immediately. The use of an ashpit or vault located directly under the grates of a furnace or boiler has been advocated from time to time. With this arrangement the home owner merely shakes the grates and the ashes drop into the vault; and at the end of the heating season, the year's accumulation of ashes are taken out.

Presumably, the same scheme could be worked with an ash-removal type stoker or even a clinkering-type stoker, except in the latter it would be necessary to pull the clinkers out of the firing door and then drop them into the pit. The principal advantage of a vault or pit is that the home owner does not have to handle the ashes and, consequently, the basement could be kept cleaner. The principal disadvantage seems to be that it is quite a big operation to remove a year's accumulation of ashes which might be as much as a ton or 1½ tons. A pit of this type also entails problems of drainage and is costly to construct.

A much simpler way of disposing of ashes, which would involve no deep construction in the home and its attendant drainage problems, is the use of ash cans with tight-fitting lids. The average home owner is able to handle a 50-pound can of ashes more easily than he can handle a larger one. The usual high-grade bituminous coal used for domestic firing, whether stoker or hand-fired, will average around 5 per cent ash, or about 100 pounds per ton. Two 15-gallon ash cans will hold this ash either in the form of clinker or in the form of loose ash from a hand-fired plant.

The ash from five tons of coal (assuming that five tons would be delivered and the ash removed by the coal truck) would require ten 15-gallon cans, which would not be particularly decorative to the basement. These could, with a little planning, be stored under the sloping ends of the coal bin, or even placed in a separate enclosure if they offend the aesthetic taste of the home owner. Cans this small could be stacked one above the other on shelves without involving a great deal of work.

The method of removing the ash or clinker from the furnace to hold down the amount of dust is very important. Clinkers are perhaps cleaner than loose ash, although it is very easy to discharge a considerable quantity of fly ash from clinkers into the basement if the clinkers are not handled properly.

The clinker should be removed from the hot part of the fire and placed in a cooler portion of the firebed and allowed to cool. The ledge in the door of a warm-air furnace is ideal for this purpose. Once the clinker is cooled, the fly ash can be shaken off inside the firebox and the clinker put in a can without adding to the dust nuisance. Loose ash, on the other hand, presents a considerable problem because there is no way of handling it in the dry state without stirring up some fly ash. The use of an ashpit spray has been variously recommended and seems a logical answer to this problem. This involves nothing more than a short piece of garden hose hooked to a convenient water outlet near the furnace. Or, water may be piped inside the ashpit of the furnace with a suitable spray head, and the water turned on when the grates are being shaken or just before the ash is removed.

Two objections are raised to the practice of spraying water into the ashpit. One is that water may accidentally strike the hot grates or sides of the firebox and cause them to crack. The other is that water will tend to rust out the ashpit of the furnace or boiler. Yet, experience generally has shown that neither of these accidents is likely to happen. Furthermore, although the ash will be considerably heavier when wet, the reduction in the dust nuisance is well worth the additional weight.

The use of special hoists, elevators, dumb waiters, or wheelbarrows designed to hold one or more ash cans, seems out of place in the average home, notwithstanding their practicality in apartment houses or other installations where a considerable tonnage of coal is burned.

The growing practice all over the country of putting the garage in the basement had tended to simplify removing ashes from the premises, because it is much simpler to carry or wheel ashes up the garage ramp to ground level. In the basementless house, the utility room is usually very cramped for space and the storage of a large amount of ash is naturally impossible. Even in this case the storage of two or three months' supply of ashes would not be difficult, inasmuch as a lesser amount of coal is burned than in the larger homes. If desired, ash storage can be made at grade level on the outside of the house in the form of a weatherproof ashpit under the back porch or a similar location. In this case, an ash-conveying mechanism, presumably from the bin-feed stoker, is practically a prerequisite. The idea back of this is to simplify the disposal of ashes and this, too, seems to be a lot of trouble for a minor job.

CONCLUSION

These few simple rules, namely, (1) locating the bin in order that the coal may be delivered to it most easily, (2) locating it in order that the coal will be easy to remove, either automatically or by hand with a minimum of effort, and (3) getting the bin of sufficient size and of dust-proof construction, are so important to the comfort and satisfaction of the occupants of the home that earnest consideration of them by every architect and builder is solicited.

The problem of ash and clinker storage is simple, and in the average home it is likely that, with a sufficient number of tight ash cans, the problem can be handled easily. More elaborate provisions may be made, but they are not absolutely necessary.

Our present knowledge of the reserves of the three major fuels—coal, oil, and gas—shows that regardless of what fuel will be used first in the homes built today, it is a certainty that the home will eventually burn coal. It is only fair to the occupants to provide for this eventual conversion in the design of the home.

DISCUSSION

R. M. Gerhardt presiding

H. W. NELSON[1]: I am inclined to agree with Carroll's observations. We don't want to put in too many fancy gadgets. It is difficult enough to figure out suitable means of burning the coal without paying too much money for gadgets, ash hoists, etc. A neighbor of mine, who has a bin-fed stoker, figured that at the end of each heating season he had about a ton and one-half of coal left in his bin which was being wasted. Last winter, in Columbus as elsewhere, we found it hard to get coal—at least coal of the type usually used. The day came when this neighbor's coal was about gone and a new supply could not be obtained from his dealer for several days. All this neighbor had to do was to move the coal out of the corners of the bin and cover the feed screw. The "wasted" coal was his factor of safety.

I think ash removal is a problem. I always appreciate this fact when I come home in the evening and have to carry out about 3 or 4 cans of ashes. However, I think some of the old-fashioned backbreaking exercise will be necessary until something practical can be done about the integration of the whole coal-heating problem at a reasonable cost.

H. R. LIMBACHER[2]: I have little to say on the subject. I agree with Dr. Nelson that it doesn't warrant a large expenditure, but I have had similar experiences in carrying ashes too far. I believe that satisfactory ash removal and coal storage, if planned in advance by the architect, can be carried out with probably no additional cost to the structure over that for inconvenient facilities.

E. T. SELIG[3]: I am interested in the views and discussion of this paper, and agree that coal bins should not have a sloping bottom. From my observation of the operation of more than a thousand stokers, those stokers which have sloping-bottom coal bins require $25 to $50 per year more for repairs than those which have bins with flat bottom at floor level.

There is no such thing as dry anthracite coal when delivered under normal operating conditions. With a sloping bin all the water from the coal is directed to the coal worm. It is the acid water from the coal, rather than abrasion, which wears out coal worms.

A flat-bottom bin has reserve storage capacity, which has proved very desirable during these days of coal shortages. Furthermore, we have found that coal flows at about the same angle from a pile of coal as it does from a sloping bottom of a coal bin.

We started building ash pits for stokers 15 years ago after a year of experience in servicing a mechanical ash remover of a prominent make. About 1938, The Anthracite Industries, Inc. published Bulletin #MA-1 on the subject of ash pits. A prominent architect of Scranton criticised the ash-pit idea so severely to some coal operators, stating that it would not work out, that Anthracite Industries' officials were called for an explanation for getting out a Bulletin on a

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1 Research Engineer, Battelle Memorial Institute, Columbus, Ohio.

2 Development Engr., Ingersoll Steel & Disc Division, Borg-Warner Corporation, Kalamazoo, Michigan.

3 Fuel Savers Inc., Harrisburg, Pa.

subject which would not prove practical. I recall that one of these officials called at my office on his way to Scranton to straighten out this matter. He wanted my suggestions. My answer was: "Maybe an ash pit won't work but we have several hundred people in Harrisburg who have used these ash pits for as long as eight years. Perhaps they are too dumb to know that their ash pits won't work." Today I could make the same remark, except to raise the figure to 2000 owners.

A Harrisburg architect who designed his own home put his coal bin under his garage. He does not find it difficult to run his car outside to let the coal men chute the coal into the bin. He has a large ash pit under his boiler, with the opening outside the building wall.

A few years ago we were asked to build an ash conveyor to remove the ashes from under the boiler and convey them to a large storage receiver outside the building, for later disposal by truck load. We declined to do this as the first cost would run from $100 upwards, with a high annual maintenance. Men engaged in ash hauling will remove the ashes from the ash pit *under* the boiler, wetting them down first, carry them to their truck, and clean the boiler flues at a price of 10 cents per bushel (present cost). Why spend a lot more money just to acquire some real headaches? One can imagine the ornamental value of a big ash receiver alongside the house.

I know several manufacturers who have discontinued making mechanical ash conveyors. One man told me that his company had lost $185,000.00 on an ash conveyor. My experiences have been with Anthracite. An ash conveyor for Bituminous coal would be subject to even more operating troubles.

Chimneys and Fireplaces

By J. W. Eckerd*

INTRODUCTION

It is the custom to link chimneys and fireplaces together for purposes of discussion. It is perfectly obvious that all fireplaces, except false ones, require chimneys, but it is not at all obvious that all chimneys require fireplaces. Chimneys (except with forced- and induced-draft systems) furnish the power (draft) to bring the life-blood (air) of the heating system to the fuel and are really the heart of the heating system. Fireplaces, as ordinarily installed, except where no other heating system is available or where the weather is mild, are luxuries and should be treated as such. To term the fireplace a luxury does not remove it from consideration for improvement as a result of experience or research, but it does place it in a position of decreased importance when emphasis is to be placed on satisfactory heating and comfort in the home.

CHIMNEYS

CHIMNEY FUNCTIONS

The functions of a chimney depend, in part, on the type of heating system that is used. Heating systems utilizing natural draft require chimneys which are high enough to create the draft necessary for the particular system, and which have great enough area to carry away the products of combustion. Systems utilizing forced or induced draft are not so sensitive to the effect of chimney height, but care must be taken to provide enough cross-sectional area to carry away the excess air and the combustion products which will be produced during the "on" periods. A greater chimney area will usually be required for a system utilizing mechanical draft than for one utilizing natural draft, as the burning rate is usually higher, and, therefore, more flue gases are formed during the "on" periods than during any period of natural draft operation. Hence, in order that a chimney may be completely satisfactory under any conditions which might arise, it should be high enough to create the proper draft for natural draft operation and have a cross-sectional area sufficiently large to carry away the excess air and products of combustion from systems utilizing mechanical draft. It is also of particular importance that the chimney be sturdy and fireproof, as well as lined with materials which offer a minimum of resistance to the flow of gases.

DETERMINATION OF CHIMNEY HEIGHT

There are a number of formulae available for calculating either the height of the chimney necessary to produce a certain draft or the draft produced by a chimney of certain height. These equations may be found in "The Efficient Use of Fuel"[1], "Heating, Ventilating and Air Conditioning"[2], "Technical Data on Fuel"[3], the "Chemical Engineer's Handbook,"[4] and in various other handbooks and texts.

* Research Assistant, Division of Fuel Technology, The Pennsylvania State College.

One of the more readily usable of these equations is that of Harding and Willard[2] which in its final form is as follows:

$$(1) \quad H = 7.64\,L\left(\frac{1}{T} - \frac{1}{T_c}\right)$$

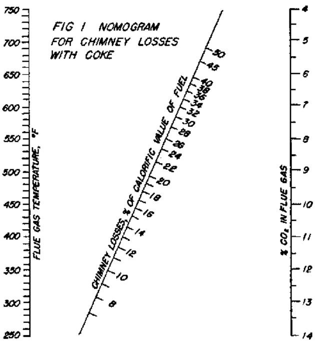
where H = the total load (or intensity of draft) produced by the chimney in inches of water

L = height of the chimney above the grate measured in feet

T = temperature of the outside air, °R

T_c = temperature of the chimney gases, °R (It is usual to take approximately 0.80 of the head, H, when the calculation has been based on the temperature of the gases leaving the boiler to allow for the cooling effect of the flue and stack; however, for average inside chimneys and average length of smoke pipe, assume the gas in the chimney is at 350°F.)

It is evident from this equation that the intensity of the draft is a function of both height of the stack and temperature of the flue gas. Obviously, a high stack-gas temperature will overcome to some extent a deficiency in the height of the stack, but this is both inefficient and hazardous because of heat losses up the stack and the danger of fire. The extent of possible stack losses is made more apparent by consideration of the nomogram prepared by R. H. Parsons[5] and shown in Figure 1.

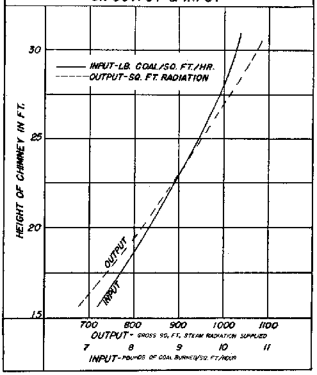


This figure clearly demonstrates that chimney losses increase greatly with an increase in stack temperature at any CO_2 content, and any attempt to increase the draft of a low chimney by raising the flue gas temperature will result in decreased over-all efficiency. For example, at a CO_2 content of 8 per cent, an increase in flue gas temperature from 300°F to 500°F will result in about an 11 per cent increase in chimney losses.

For homes, the height and size of the house must be considered in determining the height of the chimney if the general appearance of the complete unit is going to be pleasing to the eye. Some authorities claim that any flue under 40 feet will produce erratic draft under certain conditions, and it is generally recommended[2,6,7,9,10] that the height of domestic chimneys be at least 35 feet. However, if because of appearance such a height is undesirable, it is recommended that the chimney extend at least three feet above the roof of flat-roof buildings and at least two feet above the ridge of peak-roof buildings.

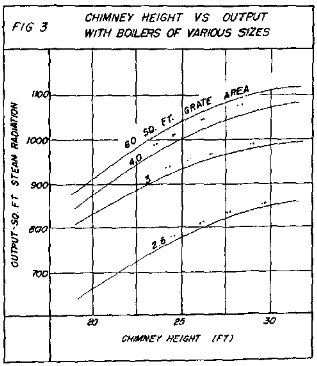
An interesting series of experiments reported by Johnson[8] shows the effect of chimney height on draft for a boiler with three square feet of grate area, as well as its effect on a series of boilers of different grate areas. It is clearly demonstrated in Figure 2 that

FIG 2 EFFECT OF CHIMNEY HEIGHT ON OUTPUT & INPUT



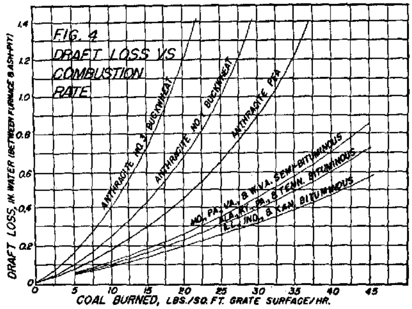
both the input and output increase with an increase in height of the stack.

Figure 3 shows the effect of increase in height upon output from various sizes of boilers. It is interesting to note that a marked increase was obtained in all cases where the height of the chimney was increased. The fact that a greater increase in output was obtained by increasing the height of the chimney from 20 to 30 feet for a boiler of three square feet grate area than by doubling the grate area, is of particular interest. This indicates that an increase in chimney height is more effective in obtaining a greater output under certain conditions than an increase in boiler size.



FACTORS OTHER THAN CHIMNEY HEIGHT AFFECTING DRAFT

The available draft is considerably reduced below the theoretical value both by the resistance of the fuel bed and by the resistance in the boiler. Figure 4[2] shows the relation of draft loss between furnace and ashpit to rate of combustion for various fuels. The force of the draft between the furnace and ashpit increases quite appreciably as the burning rate increases and as the size of the fuel decreases.



Johnson[8] reported the draft resistance of six commercial boilers, all of which had approximately three square feet of grate area and were tested with the same chimney. These boilers showed resistances varying from 0.014 to 0.094 inches of water due to the difference in design.

The object in improved boiler design is to extract more heat from the flue gases. Improvements in boiler efficiencies may result in increased resistance in the boiler and are certain to produce lower stack temperatures, with the result that the actual draft may be considerably less than that calculated by equation (I). If this should prove to be the case, it may be necessary to utilize mechanical draft (forced or induced) in order to overcome the increase in resistance and decrease in temperature which may result from more highly efficient boilers.

DETERMINATION OF CHIMNEY AREA

The area of the chimney is determined by the volume of flue gases passing up the chimney, which in turn depends on the weight of fuel burned, the amount of air supplied for combustion, and the average temperature of the flue gases. Table I shows the theoretical air required for a series of typical fuels. The total mass of flue gas will be approximately the same as the mass of air entering; any increase is due to the amount of moisture in the fuel. (The heated flue gas will be in greater volume than the entering air.)

TABLE I. Theoretical Amount of Air Required per pound of Fuel

Fuel	*% by weight* *% C*	*% H*	*% O*	*Cu ft of Air per lb of Fuel @ 60°F and 30" Hg*	*Lb of Air per lb of Fuel*
Peat	56.4	5.44	33.5	90.3	6.88
Lignite	70.5	5.1	21.5	116.8	8.91
Sub-Bit.	76.6	4.8	17.0	126.7	9.66
Bituminous .	87.1	5.9	5.1	154.5	11.78
Semi-Bit. ...	90.3	4.75	3.0	155.4	11.84
Anthracite ..	94.0	2.68	1.7	150.4	11.46
Coke					
Min. Oil ...	86.0	12.0	1.0	182.6	13.92

The theoretical amount of air required per pound of fuel for either anthracite or bituminous coal is usually assumed to be about 11.7 pounds[2], and since about 50 per cent excess is normally used, 19.05 pounds is approximately the amount of air admitted per pound of fuel burned. To simplify calculations, a value of 20 pounds of air per pound of fuel is generally used in practice.

The volume of flue gas resulting at any combustion rate may be computed by use of the following equation, with the assumption that the density of flue gas is the same as that of air at the same temperature and pressure:

$$(2) \qquad Q = \frac{C \times W}{d_c \times 3600} = \frac{C \times W \times T}{39.7 \times 3600} = \frac{C \times W}{39.7} (460 + t_c) \frac{1}{3600}$$

where Q = volume of flue gas in cubic feet per second per square foot of grate area

C = combustion rate in pounds of coal burned per hour per square foot of grate area

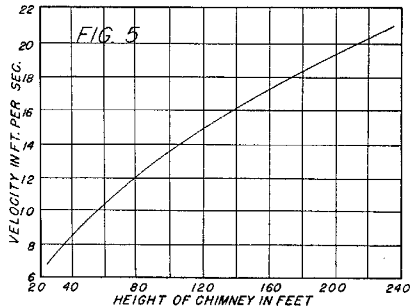
W = weight of flue gas per pound of coal burned, taken as 20 lb

t_c = temperature of flue gas in °F

d_c = density of flue gas in pounds per cubic foot, taken same as air = $\frac{39.7}{T_c}$

where T_c = absolute temperature of the flue gas in the chimney or, $T_c = (460 + t_c)$.

The rate at which the gases travel in the chimney is also necessary in determining the chimney area. Figure 5[2] provides a method of determining the velocity of the gases for chimneys of various heights. The velocities vary approximately as the square root of the height of the stack in this figure.



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It is significant to note that Harding and Willard[2] observe that any analysis of a chimney problem will usually give flue areas that are too small for small boilers with grates under five square feet in area. To take care of this, they recommend that two inches be added to the computed diameter of any flue under ten inches.

CHIMNEY CONSTRUCTION

Construction requirements for chimneys are presented in full by the National Board of Fire Underwriters[7], the U. S. Department of Commerce[9], American Society of Heating and Ventilating Engineers[10], and by various other government agencies and private concerns. A summary of the essential features obtained from the above sources follows:

(1) Chimneys shall be built upon concrete or masonry foundations properly proportioned to carry the load without danger of settlement or cracking. The footing for any exterior chimney shall be below the frost line.

(2) The walls of brick chimneys shall not be less than

3¾ inches thick (width of standard brick) and shall be lined. Flue linings may be omitted in brick chimneys for residence buildings provided the walls of the chimney are not less than eight inches thick and the inner course be of refractory brick. The linings shall be at least ⅝ of an inch thick and shall be suitable for the purpose and adapted to withstand high temperatures and the resultant gases from burning fuels.
(3) All brickwork shall be laid in spread mortar, with all joints brush filled. No mortar linings shall be permitted.
(4) Hollow masonry units shall not be used for walls of an independent chimney but may be used for chimneys built in connection with exterior walls of buildings constructed of hollow units, in which case the chimney walls shall be at least eight inches thick.
(5) There shall be but one connection to the flue to which the boiler or furnace smoke-pipe is attached. Smoke-pipes shall not project into the chimney beyond the surface of the flue lining.
(6) Connections between chimneys and roof shall be made with sheet-metal cap and base flashing arranged to allow for any lateral or vertical movement between the chimney and the roof.
(7) The construction and size of flues to be used for oil- and gas-fired furnaces, boilers, and automatic water heaters shall be the same as required for corresponding appliances burning solid fuel.
(8) Mortar used between the joints of the flue linings and in the portions of a chimney above a roof, or otherwise wholly exposed, shall be mixed in proportions of one part Portland cement to not more than three parts of clean sand. Firebrick when used for linings of flues or facing the interior of fireplaces shall be laid in fire clay mortars. All other mortar used in chimney construction shall not be heavier than the following mix by volume: one part Portland cement, one and one-quarter parts hydrated lime, six parts clean sand, thoroughly mixed to a uniform color before wetting.

A factor which deserves more consideration than it usually receives in chimney construction is the size and position of the clean-out door at the base of the chimney. This door should be constructed so that it is readily accessible when removing the fly-ash and soot from the chimney, and should be large enough and in such a position that a shovel may be conveniently used. It should also be far enough below the point where the flue gases from the boiler enter the chimney so that a considerable quantity of fly-ash can accumulate without affecting the draft or free-flow of the gases in order that cleaning is not required at too frequent intervals. At the same time, however, the fly-ash pocket should not be large enough to hold sufficient air to cool the flue gases appreciably or to affect the draft in any way, and it is recommended[2] that the flue be not extended any greater distance beyond the smoke-pipe opening than is necessary for the door.

FIREPROOFING OF CHIMNEYS

Fire-proofing of chimneys is fully as important as any other item to be considered in construction. Fire statistics[11] show an annual fire loss of $40,000,000 resulting from overheated or defective chimneys and flues. This is considerably higher than any other known cause of fire loss. It is recommended[7] that no wooden beams, joists, rafters, or studs be placed within two inches of chimney walls and that no woodwork should be placed within four inches of the back wall of any fireplace. It is also recommended that all woodwork immediately adjacent to chimneys be protected by insulation.

Unquestionably not all this fire loss can be laid to faulty construction, because age, neglect, soot, and various other factors all contribute to the hazards; but it cannot be over-emphasized that all precautions should be taken to make chimney construction fireproof.

CHIMNEY SHAPE

The most efficient shape for a chimney, according to all available information, is one built perfectly straight with a round or nearly round flue and a smooth interior surface. Flue gases, according to theory, ascend with a spiral motion and the circular flue offers less resistance to their motion than square, oblong, or elliptical flues. Cost of materials and ease of construction appear to be the factors influencing the construction of flues with shapes other than round. With rectangular chimneys, soot may collect in the corners and present an additional fire hazard, as well as create an added resistance to the flow of the flue gases.

CHIMNEY LOCATION

Chimneys located inside the house are generally more satisfactory than those outside. Since draft is a function of the temperature of the chimney, an inside stack will have not only the advantage of increased draft due to a higher flue gas temperature, but also the advantage of not being so directly affected by changes in outside temperature. Also, with an inside chimney a certain amount of heat in the flue gas will be given up to the building; on the contrary, with an outside chimney, the heat will be dissipated to the atmosphere.

CHIMNEY CONCLUSIONS

The chimney, the heart of the heating system, unquestionably deserves more attention than it usually receives. A complete set of standard specifications would appear to be necessary to insure health and comfort to the individual and safety and cleanliness to the community. These chimney specifications should include requirements which will insure: (1) sufficient draft for any type of heating system utilizing any kind of domestic fuel, (2) a cross-sectional area great enough to carry away the products of combustion with minimum resistance at any burning rate, and (3) sturdy and fireproof construction. The shape and location of the chimney should also be specified. There are sets of specifications published by various agencies and organizations that are excellent for their purpose, and perhaps the logical step would be to get all such plans together and present one complete set of specifications which will embody the opinions and experience of all the various organizations.

FIREPLACES

FIREPLACE EFFICIENCIES

To label a fireplace a luxury in view of the fact that it is one of the oldest methods of househeating may seem a bit harsh; nevertheless, because of its low efficiency (usually 5-15 per cent) in ordinary installations, there appears to be no recourse. The only warming effect is produced by radiation from the back, sides, and hearth, while practically all the air which could warm by convection goes up the chimney. Tests made by the Bureau of Agricultural Chemistry and Engineering[12] show that five times the amount of air required even for liberal ventilation may be drawn into a living room by operation of a fireplace. Such excessive ventilation is almost sure to cause drafts and will lower the temperature of the parts of a room that are near windows and doors. Further tests by the same Bureau indicate that, as ordinarily constructed, a fireplace is only about one-third as efficient as a good stove or circulator heater. However, the cheerfulness and hominess provided by a fireplace cannot be denied. As a result, careful consideration should be given to construction and improvement in operation so that the fireplace may be made as efficient as is possible.

RESEARCH

It might be well to note that very little research on fireplaces is reported in the recent technical literature in the United States. In England, however, where open fires are still regarded as one of the more satisfactory methods of heating, a considerable amount of research was reported even during the war years. Examination of the British Coal Utilization Research Association's abstracts for the years 1943, 1944, and 1945 shows that over 25 British patents were granted for improvements in fireplaces and fireplace grates.

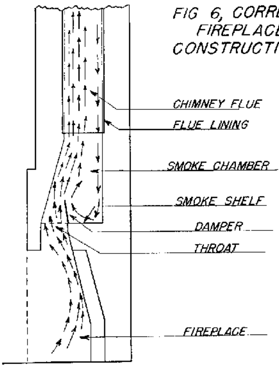
FIREPLACE ESSENTIALS

There are five essentials to be considered in building a satisfactory fireplace.[6,12] They are: (1) proper area of the flue, (2) correct location and size of the throat, (3) properly constructed smoke shelf and chamber, (4) a chimney which will provide a suitable draft, and (5) a shape that will radiate a maximum amount of heat into the room.

FLUE AREA

The area of the flue for a fireplace should have a direct relationship to the fireplace opening. The area of lined flues, as recommended by the National Coal Association,[6] is 12 per cent or more of the area of the fireplace opening. When flues are unlined, they should be larger; but it is very difficult to predict the minimum size because of the variations in the surface of the materials used for construction. The cross-sectional area of the flue should be maintained constant over its entire length, and if it is necessary to change the direction of the flue, the full area should be maintained in all curves and bends. Any curves and bends in the flue should be as gradual as it is possible to make them.

FIG 6, CORRECT FIREPLACE CONSTRUCTION



THROAT

The throat, as shown in Figure 6, is the opening between the fireplace and the smoke chamber. The area of the throat should not be less than that of the flue, and the length of the throat should always be equal to the width of the fireplace opening. The sides of the fireplace should not be drawn in until the throat is passed. After this point it is possible to draw in the sides without any likelihood of causing smoking. The width of the throat is determined by the opening of the damper cover. The full damper opening should never be less than the area of the flue.

SMOKE SHELF

A smoke shelf is essential in fireplace construction to change the direction of the down draft as shown by the arrows in Figure 6, so that the hot gases from the fire, after passing through the throat, will strike it at approximately right angles. The smoke chamber is the space between the side walls, extending from the top of the throat to the bottom of the flue proper (Figure 6). Its purpose is to hold accumulated smoke temporarily in case the draft in the chimney is momentarily shut off, and to cut down the force of the down draft by increasing the area through which it passes.

CHIMNEY

Fireplaces, in common with all other heating installations, can only function as well as the chimney design permits them, and as a result the details presented for chimneys in the first part of this paper should apply to fireplace chimneys, as well as to chimneys for any other heating installation.

FIREPLACE SHAPE

The shape of the fireplace should be such that a maximum amount of radiation may take place. The sides should be beveled and the back should pitch forward from a point, usually designated as less than half way between the hearth and the top.

DAMPER

A properly designed throat damper is another necessity of every successful fireplace since it affords a means of regulating the draft, as well as prevents excessive heat losses from the room when the fireplace is not in use. Smoke dampers with the lid hinged at the back are usually the most successful type because they also help the smoke shelf to change the direction of the down draft.

MODIFIED FIREPLACES

The inefficiency of an ordinary fireplace may be lessened by the installation of an improved fireplace which utilizes some of the heat, normally lost up the chimney, for convection purposes. There are a number of types of these improved fireplaces, one of which is shown in Figure 7. Some of these installations may be

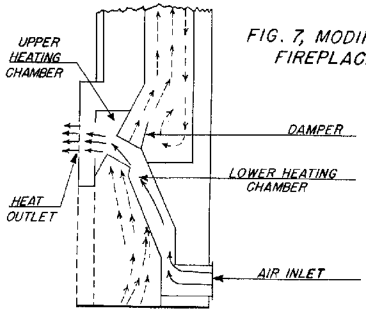


FIG. 7, MODIFIED FIREPLACE

purchased as units and built into the house with the regular construction in such a manner that they are concealed by the usual brickwork. Field tests made by the Bureau of Agricultural Chemistry and Engineering(12) have proved that, when properly installed, the better designs of these "modified-fireplaces" circulate heat into cold corners of rooms and will deliver heated air through ducts to adjoining or upper rooms. The Bureau also measured the quantity and temperature of the heated air discharged through the grills of an installation of the type shown in Figure 7 to determine the merits of the convection features. Enough heated air was delivered from the discharge grills of some of the medium sized units tested to represent a heating effect equivalent to that from nearly 40 square feet of cast-iron radiation of the ordinary hot-water heating system. Additional heat may be made available in some units by the use of forced circulation fans.

Despite these improvements, the inherent nature of fireplaces, which allows large quantities of heated air to pass up the chimney, makes the efficiency of any fireplace low, and any improvement which can be made serves only to make the fireplace relatively less inefficient. Increased efficiency can certainly be obtained with the improved fireplaces, but it is only with respect to other fireplaces, and not as an improvement over stoves and centralized heating plants.

CONSTRUCTION

The construction and building materials for fireplaces should embody all the characteristics of strength and fireproofing demanded for chimneys. The footings for fireplaces should be as substantial as those described for chimneys. The following additional requirements are the most essential of those proposed by the Bureau of Agricultural Chemistry and Engineering.(12)

(1) Hearths should project at least 16 inches from the chimney breast and should be of brick, stone, terra cotta, or reinforced concrete not less than the width of the fireplace opening plus 16 inches.

(2) The walls of fireplaces should never be less than eight inches thick, and if of stone, they should be at least 12 inches thick. It is advisable to line the back and sides with fire brick laid in fire clay. When a grate for burning coal or coke is utilized, fire brick, at least two inches thick, should be added to the rear wall of the fireplace. If the grate has a solid iron back, an air space behind it is sufficient.

(3) The jambs should be wide enough to give stability and a pleasing appearance. When a masonry arch is used over the opening, the jambs should be heavy enough to resist the thrust of the arch. The edges of a wood mantel should be kept at least eight inches from the fireplace opening.

(4) Lintels of ½- by 3-inch flat iron bars, 3½- by 3½- by ¼-inch angle irons, or damper frames are used to support the masonry over the opening of ordinary fireplaces.

FIREPLACE CONCLUSIONS

Fireplaces, although inherently inefficient, should have the following details incorporated in their construction in order that as high a degree of satisfaction and comfort as is possible may be attained.

1. Adequate flue area.
2. Correct throat dimensions.
3. A smoke shelf and adequate smoke chamber.

4. A carefully constructed chimney.

5. A shape resulting in maximum radiation.

6. A suitable damper.

7. Convection facilities for utilizing some of the heat usually lost up the chimney.

ACKNOWLEDGEMENT

The author wishes to express his appreciation to all those who were of assistance in various ways in the preparation of this paper, particularly the following: K. C. Richmond, R. C. Johnson, C. T. Bissell, and S. Konzo for making available much of the information presented; to C. C. Wright and T. S. Spicer for constructive criticism of the text; and to J. D. Clendenin and H. T. Grendon for assistance in preparation of the figures and slides.

DISCUSSION

R. M. Gerhardt presiding

A. W. GAUGER: I would like to point out a few things not connected with design or engineering but which are important. One of the important things in fireplace construction is to be sure that the job is done properly. Frequently, insufficient care is taken in the actual construction. The flue liner is an important thing. Sometimes it is poorly installed, with mortar sticking out; thus, creating resistance to the flow of gases, and offering an opportunity for trapping of moisture. One specific instance that came to my attention was a badly smoking fireplace. Examination of the throat revealed large gobs of mortar and a few pieces of timber that had not been cleaned out when the house was built. Removal of this debris changed the situation entirely.

R. M. GERHARDT: The specific remarks made by Dr. Gauger concerning difficulties experienced with fireplaces reminds me of an instance in State College some years ago. While the chimney was being constructed, a straw-filled bag suspended from a rope was pulled up through the chimney to prevent a lip. Someone forgot to take the bag out of the chimney—you know the result.

On another occasion a professor had done research work on fireplaces and studied extensively in the architectural library. He thought he had the ideal fireplace design. When the craftsman looked at the drawing he said, "Now, Professor, would you like to have the fireplace built like this, or built so it won't smoke?"

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Economics of Insulation

By Wharton Clay, Architectural Engineer*

ACCORDING to the U. S. Bureau of Mines, a billion dollars worth of fuel is wasted annually in the houses of this country; this estimate is based on a general average saving of $25 per year for an insulated house. When more houses are built, there will also be more waste, if these houses are not built in a way to economize to the fullest extent on fuel. Based on the average fuel waste (or saving) figure cited above and on an estimated construction of only 500,000 houses per year, the potential waste, if the houses are not fully insulated, would be $12,500,000 the first year, $25,000,000 the second year, $37,500,000 the third year, and so on, until by the end of the tenth year it would amount to $125,000,000 annually.

Moreover, if the goal of ten million houses in ten years is reached, rather than the five million indicated above, the fuel *waste* would total $250,000,000 annually. Certainly, this $125,000,000 to $250,000,000 of additional waste should go a long way toward pay- the interest on the National Debt. When insulation is considered in the light of its effect on the National Economy, very substantial amounts of money are involved.

The use of Mineral Wool as an example in this discussion is both pardonable and understandable. It serves the purpose very well, for it is manufactured in different thicknesses in the form of bats and blankets, and can be installed in any thickness desired in the loose or granulated form. In this discussion it will also be appropriate to examine the relative merits of various thicknesses of insulation, not only from the standpoint of fuel saving, but also from the standpoint of human comfort, which is pertinent in the definition of economics and related words.

There are many ways of approaching this subject, "Economics of Insulation," but let us first think of the broad general approach rather than the detailed technical questions of "k" factors[1], "U" factors[2], etc. Let us consider the ownership and maintenance of a home as a business venture. Then, the decision does not lie in the choice of what materials, thicknesses, and areas will produce the greatest percentage of fuel saving over the investment, but rather in what materials, thicknesses, and areas will produce the greatest dollar return, providing they can be financed so that the carrying charges of the investment do not eat up the savings. Thus, it may be wise economy to invest more money to get large net dollar returns rather than to invest less money and secure a more attractive net percentage of interest. Furthermore, there are advantages other than fuel savings when it comes to insulation, advantages such as (a) summer comfort, (b) winter comfort, (c) high wall temperatures in winter, (d) low wall temperatures in summer, (e) fire resistance, and other advantages that cannot be counted in dollars and cents, but are nevertheless encompassed in the Economics of Insulation because they add a material value to the building. Moreover, the importance that can be attached to any of these features is definitely related to the insulation value or thickness of the insulation as installed.

The values added to a home which are not included in fuel savings are definite improvements in the desirability of the house and are termed "amenities." These will be discussed in more detail later, and it will also be

* Secretary, National Mineral Wool Association, New York, N. Y.

[1] This term, "k" factors, refers to the thermal conductivity coefficients of different building materials (and insulators); these coefficients are commonly expressed in Btu per hour per square foot per degree Fahrenheit per 1 in. thickness of the substance.

[2] This term, "U" factors, refers to the coefficients of heat transmission for different types of construction (brick, frame, etc.); these coefficients are commonly expressed in Btu per hour per square foot per degree Fahrenheit difference in temperature between the air on the two sides of the construction.

shown how it is possible for the absence of insulation to be a basis for rejection of a mortgage under the F.H.A.

FEDERAL RESERVE BANK BOARD INDORSEMENT

A profound indorsement of substantial insulation and other fuel-saving devices was made early in the war when the Board of Governors of the Federal Reserve System issued Regulation W to implement the President's policy of reducing inflationary spending.

Under Regulation W, the allowable duration of time payments on practically all items of consumer goods was reduced from 36 months to 12 or 18 months and on many items a down payment was exacted. On insulation within structures and other fuel-conservation devices, no down payment was required and time payments could continue for as many months as could be negotiated with the lender.

This action, which was in the opposite direction from the trend of the financing policy for the war, is prima facie evidence that substantial insulation and its consequent fuel saving has won its rightful position in the National Economy.

INSIDE WALL AND CEILING TEMPERATURES

Engineers are familiar with the fact that comfort is not entirely registered by a thermometer. The most impressive lesson for anyone would be to go into a vacant, unheated house, as in Figure 1, on some bleak

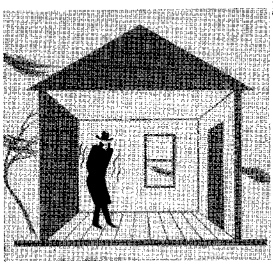
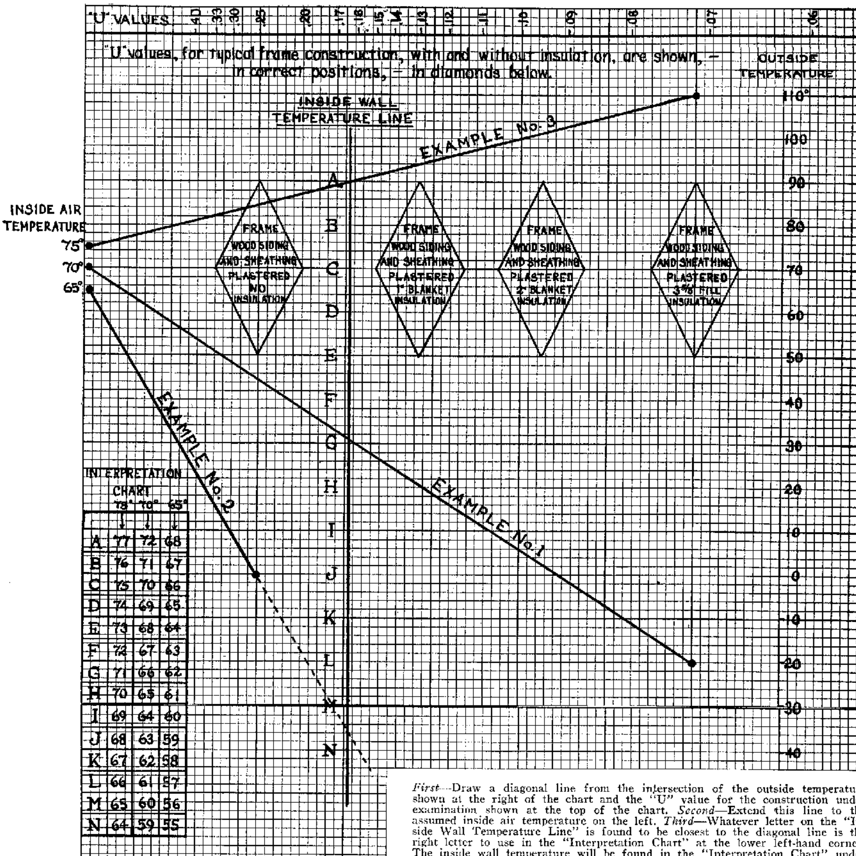


FIGURE 1

day and note how it seems even colder in the house than out of doors. The reason is, one's body is closely surrounded by cold surfaces, and the surfaces are robbing it of heat. The same effect is experienced when the house is heated to say 70° air temperature and the walls are uninsulated. The degree of comfort is indicated by the temperature of the inside surface of the outside walls, as shown in Figure 2. Example No. 2 shown on the Inside Wall Temperature Indicator Chart is for the normal frame construction with wood siding and sheathing, plastered but with no insulation, in which it is common practice to use a "U" value of 0.25. It will be noticed in this chart, that with the outside temperature at zero and the inside air temperature at 65°, the inside wall temperature is 10° below the room temperature. However, if full-thick Mineral Wool is used, as in Example No. 1 and temperature −20° with inside temperature at 70°, the wall temperature is only 4° less than room temperature. Whereas, if one inch insulation is used at 20° below zero, the wall temperature is about 6° below the indoor temperature. Now, this difference between a wall temperature 4° lower than the room temperature or 10° below the room temperature is a very important temperature difference. The addition of the extra two inches of insulation produces a marked difference in the wall temperatures, and adds a comfort sensation which cannot be calculated in dollars, but can be evaluated in the terms of desirability by an expert in a different classification than the engineer; namely, the appraiser or valuator.

In Figure 3 is shown a very interesting relationship which has been calculated by the engineer simply on the basis of fuel savings and the close connection between added comfort and added fuel savings. This chart, showing annual savings in fuel cost per 100 square feet of insulation based on the climate of Chicago and 7-cent fuel oil, indicates that as the comfort rating improves, the dollar value of the savings also improves. Only in insulation does this remarkable relationship exist wherein the greater the amount of money that is spent for insulation, the greater the fuel savings and the greater the comfort.

Recognition of the importance of wall insulation is not sufficiently widespread because the public has the conviction that heat rises and does not go sidewise. Consequently, it is assumed that ceiling insulation is more important for heat conservation than is wall insulation. Furthermore, the public does not know enough about the effect of cold wall temperatures on comfort. Instead, it knows more about wall insulation rates in existing houses, where it usually costs more per square foot to install mineral wool in the walls than in ceilings because of the inaccessibility of the former. Fortunately, in new construction it costs no more, and possibly even less, to insulate walls than to insulate ceilings.



First—Draw a diagonal line from the intersection of the outside temperature shown at the right of the chart and the "U" value for the construction under examination shown at the top of the chart. *Second*—Extend this line to the assumed inside air temperature on the left. *Third*—Whatever letter on the "Inside Wall Temperature Line" is found to be closest to the diagonal line is the right letter to use in the "Interpretation Chart" at the lower left-hand corner. The inside wall temperature will be found in the "Interpretation Chart" under the assumed inside air temperature to the right of this letter.

FIGURE 2

Engineers, on the other hand, are familiar with the fact that heat loss per square foot through walls is as heavy a drain on the fuel budget as heat loss through ceilings, and that the heat-robbing effect of walls is more serious than the heat-robbing effect of ceilings because of human proximity to walls. In fact, wall insulation is more important than ceiling insulation from the comfort or economy standpoints because of the greater areas involved. Both one-story and two-story houses have more wall area than ceiling or roof area. This is illustrated in Figure 4 in which a one-story house is unfolded to show the relationship of the area of walls and ceilings. In the two-story unfolded house, this wall area shows up as even more important.

This is only natural because the hollow spaces between the studs are usually surrounded by combustible material on all sides. This makes a perfect avenue for a fire at any lower point, such as the basement, to spread rapidly throughout a frame structure. Attic fires are all too numerous, but, as pictured in Figures 6 and 7, the ability of Mineral Wool to stop fire at the point where this insulation lies against the rafters or studs renders the house much more fire resistant than without the inclusion of Mineral Wool. Many roof or attic fires start from outside of the house either from lightning, burning firebrands, crossed wires, or other interior causes. When an attic fire is started, no better proof of the fire resistance that Mineral Wool adds to any construction could be exhibited than is shown in Figure 8.

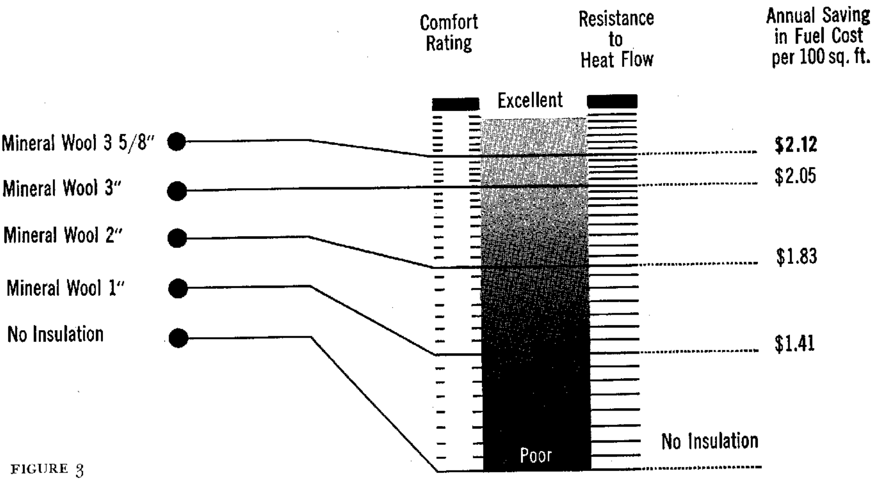


FIGURE 3

The most authentic information that can be offered as to the economic value of a Mineral Wool filling for the entire space of the studs is from studies by the National Bureau of Standards wherein tests showed that Mineral Wool in a partition (or wall) will add 20 to 30 minutes to the fire resistance of such a wall.

FIRE RESISTANCE

Although this discussion has been concerned with frame houses, the remarks to be made regarding fire resistance of roofs will, of course, apply to both frame and masonry houses. Houses of frame construction are generally recognized as a hazardous form of construction as Figure 5 illustrates.

This is because the wool prevents combustion by covering the wood with a layer of totally incombustible fibers.

It must be pointed out that one of the reasons for using Mineral Wool insulation as a fire-resistant material resides in the incombustibility of the fibers forming the insulation. Much publicity has been given to the value of incombustible fire stops for preventing the spread of fire. Such methods were specifically suggested to the lenders of mortgage money by the Federal Housing Administration in cooperation with the 1945 Fire Prevention Week proclamation of President Harry S. Truman. The Bureau of Standards in 1923 recommended the use of Mineral Wool as fire-stopping material in the joints of floors and walls in Mt. Vernon so that there would be no question of a complete engulfment of that national shrine should a fire take place.

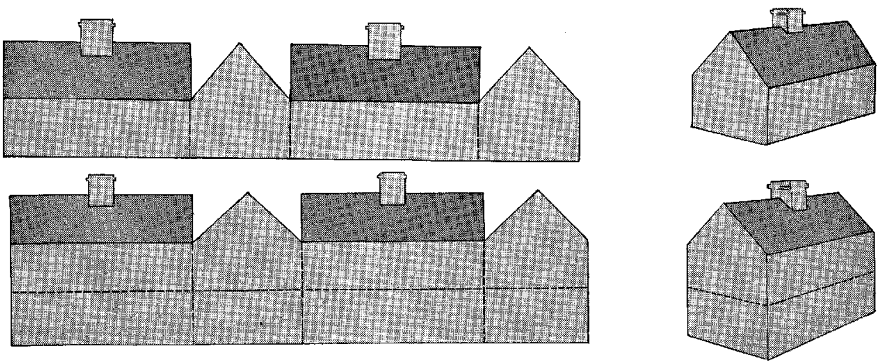
If there is any doubt as to the public desire for fireproofing, one need go no further than the recent survey made by the Curtis Publishing Company. A weighted sampling was held throughout the United States, with the result that the average percentage of all groups which specifically desired fireproofing in their houses was 71.5 per cent. Furthermore, these people were willing to back their desire by a median estimated expenditure of $192. Inasmuch as the public was thinking of an average house of about $6000 including the lot, this willingness to spend $192 for fireproofing such a house gives a very definite measure of the importance placed on this item. Such a house could be completely insulated with full-thick Mineral Wool at very little more expenditure. Thus, fireproofing must be considered as one of the major factors in the Economics of Insulation when it is of such a character and thickness that it will do a fireproofing job.

EFFECT OF INSULATION ON THE INITIAL COST OF HEATING PLANT

In new construction, to which this Housing Conference is dedicated, the initial cost of the heating plant is substantially reduced if maximum insulation is placed in both walls and ceilings. This initial saving should, of course, be deducted from the initial cost of the insulation. Depending upon the design temperature in the locality in which a house may be built, this deduction will run from 10 to 15 per cent to almost the entire cost of maximum insulation.

In a recent issue of *Performance*, published by the National Mineral Wool Association, an analysis was made of the Btu requirements, with and without insulation, for a single corner room calculated accord-

FIGURE 4



ing to the recommended practice of the Institute of Boiler and Radiator Manufacturers. The Btu difference in this room was 5200 and the difference in radiation was 28.2 square feet saved in one room of a six-room house. The total saving for the entire house would be at least four times these figures.

The Warm Air Heating and Ventilating Association also has a recommended method of calculating furnace sizes which was prepared by Professor S. Konzo of the University of Illinois. On the basis of this recommended practice, and using the typical house illustrated in their Code and Manual No. 7, the heat loss in the uninsulated house is 74,460 Btu while with full-thick insulation in walls and ceilings or floor area, the heat loss is 50,066 Btu, or a total heat saving of 24,394 Btu. This is the reduction in Btu rating recommended by the manufacturers of furnaces.

FIGURE 5

SPECIFIC EXAMPLES OF FUEL SAVINGS

The exact percentage of fuel saving to be expected from insulation of different thickness cannot be calculated satisfactorily, because of the human element of firing and the idiosyncracies of heating plants. Probably the best method of determining the heat saving is a matter of experience, particularly when identical houses have different methods of insulation or different thicknesses of insulation and the fuel savings are automatically recorded in the same winter. The insulation industry has many examples in which the savings of fuel from one winter to another run as high as 50 and 60 per cent; but there is always the question of the differences due to degree-day variations and similar items in such small experiments with a single house in different winters. Therefore, too much reliance should not be placed on this method of determining fuel savings.

FIGURE 6

There have, however, been several series of experiments in identical houses oriented in the same direction and located close together. The author is doubtful of the accuracy of the determinations made even in identical houses where one house is exposed differently from another or maybe on a higher or lower piece of ground or otherwise differently protected. Some tests of this nature have been made and only serve to confuse the situation, because generally

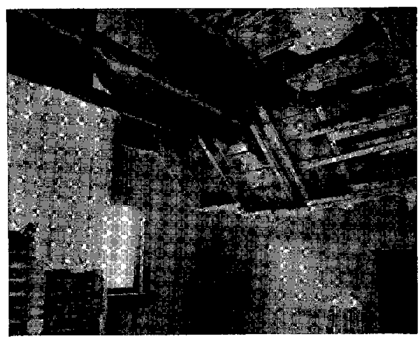


FIGURE 7

the results are quite contrary to what would be expected from a careful application of the method illustrated in the *Guide* of the American Society of

FIGURE 8

have been encountered in the insulated house occupied by the daughter, because there were two children and thus, the infiltration losses were undoubtedly greater.

Nevertheless, during the eight-month test period the comparative loss of fuel oil in the uninsulated house occupied by the mother, was 22.3 per cent, or a total of 504 gallons of oil, and with oil at 7 cents a gallon, this amounted to $34.84 lost—never to be regained. When it is realized that the monthly payments on the house for interest, amortization, taxes, and insurance amounted to $29.74, it will be readily seen that the yearly fuel saving in the insulated house was greater than one month's installment on the mortgage payment. Surely, this is a fine record in itself and is certainly related to the Economics of Insulation.

A very interesting situation developed in these two houses. The owners had been instructed to keep their thermostats at any point they chose, and if the thermostat were turned down at night, it should be done in both houses. The women were very conscientious, because they were greatly interested in the experiment themselves. Along near the end of the test, they started "fiddling" with the thermostats to see if they couldn't get equal comfort in the two houses at some certain

Heating and Ventilating Engineers, which can be relied upon quite closely.

Probably the most accurate test on two identical houses—one with no insulation, the other with full-thick Mineral Wool—was made by the Tennessee Valley Authority; both houses were electrically heated. Families were living in both houses and were under restrictions to use the doors only at certain times of the day during the period of the test; this was facilitated by the fact that the husbands in each case kept exactly the same hours. This seems like a reliable test, for it has been reported by a governmental authority that had no interest other than a scientific one, and the accuracy of measuring the heat input by electricity cannot be improved upon. This test showed 44.7 per cent saving in the insulated house as compared with the uninsulated one.

Another test, probably less accurate than the foregoing one, was conducted on Long Island in two identical houses; the houses in Figure 9 are not the two houses involved. The test houses were separated by another house in order to prevent monotony in design, but two adjacent houses are shown in the figure to give prima facie evidence of the heat savings in wintertime by the insulated floor in the unfinished attic. This test was conducted by a mother and her married daughter. If there was any unbalance in the test, it was in the greater heat losses likely to

FIGURE 9

temperature. However, they quickly came to the conclusion that for some mysterious reason, which they couldn't understand, the insulated house was more comfortable. The women asked how they could keep the houses at equal comfort, whereupon it was explained to them that when the test period was finished, they could set their thermostats at different points. But, in the meantime, they could experiment with equal thermostat settings to see whether they could arrive at equal comfort. This was tried at several different thermostat settings—it was always found that they were not getting equal comfort.

Along in the spring, however, they were permitted to abandon the test and experiment freely to develop equal comfort if they could. Finally, they arrived at

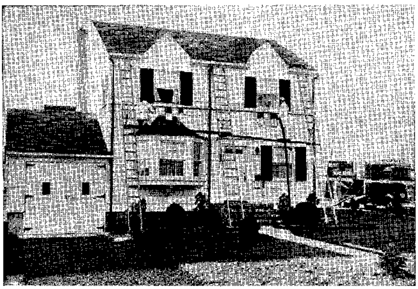


FIGURE 10

the decision that the best comparative setting was with the thermostat five degrees higher in the uninsulated house than in the insulated house. This confirms earlier studies made in laboratories where it was possible to vary the wall temperatures. It should be noted that the two women were able to reach approximately equal comfort only with a five-degree difference in air temperature between the insulated and uninsulated houses.

Another test on identical houses was conducted by two separate families in which the breadwinning members of both families were employed at the same location and, consequently, kept the same hours; all persons were adults. In this case, however, one house had ceiling insulation only and the other had both ceiling and wall insulation. These houses were identical with that shown in Figure 10.

During the period from December 1, 1941, to May 31, 1942, these houses, located in Belleville, New Jersey, showed, on equal thermostat settings, a record of 29 per cent less oil for the fully insulated house compared with the partially insulated one. Based on fuel oil at 7 cents per gallon, there accrued a saving of $23.80 solely because of the addition of side-wall insulation, a saving which is even higher than that calculated for this house from the A.S.H.V.E. *Guide*. In many instances experiences like this are encountered because houses are not always suitably tight at the sill-plate, and wall insulation, whether in batts as in new construction or blown in loose as in existing construction, cuts down infiltration tremendously.

OPTIMUM THICKNESS AND INSTALLATION COST

Let us review an article published in *Architectural Forum* for March, 1940, entitled "Insulation Economics" by E. J. Rodee of the John B. Pierce Laboratory of Hygiene, New Haven, Connecticut. Mr. Rodee made a serious study of the relation of various thicknesses of insulation to various costs of fuel to determine the optimum thickness of Mineral Wool insulation in various climates. By optimum thickness he meant that thickness of insulation which if any more money were spent for insulation, the carrying charges would be greater than the savings in coal, and if any less money were spent for insulation, the savings on coal would be lower than the carrying charges on the Mineral Wool. As an example, a two-story house of about 512 square feet of ground area was used.

In the climate of Norfolk, Virginia, the optimum thickness was two inches in ceilings and one inch in walls on the basis of stoker-burned buckwheat coal at $7.75 per ton*. This optimum thickness would have changed to two or three inches if more expensive fuels were used. Moreover, with this coal, there was a difference of 46 cents per year between one-inch and four-inch insulation. Of couse, the summer factor in Norfolk would easily have been worth this 46-cent difference.

* Coal has advanced in price since this study was completed; hence, the value of the thicker insulation will be correspondingly greater.

For the climate of Milwaukee, Wisconsin, the optimum thickness was six inches in the ceiling and four inches in the walls, and there was a net difference between the insulated and uninsulated house of $13.69 per year. Another interesting observation of Mr. Rodee was that after a 20-year amortization had been completed and the insulation paid off, there would be an annual saving of $21.40 per year.

It is not the purpose of this paper to delve too deeply into the details of the relative cost versus the amortization factor for various thicknesses of insulation because there have been many studies made on this subject by independent thinkers.

Instead, let us brief what was presented in 1940 by W. T. Miller, Associate Professor of Heating and Ventilating Engineering at Purdue University, in a study of the relation of insulation thicknesses to the net return from an investment in Mineral Wool. As can be seen in Figure 11, the total heating cost for a 20-year period shown in curve A continues to decrease with slightly less rapidity as the thickness increases from one inch to four inches. Conversely, the total saving in cost of heat is shown in curve B. Applying the reduced cost per inch of thickness for Mineral Wool material and labor shown in Figure 12, it is apparent that curve C in the previous figure shows an ever-increasing net return on the investment as the thickness of the Mineral Wool is increased. Below curve C, curve D indicates the total return if equal money were invested in four per cent securities. As four per cent is on the border line of insecurity under present interest conditions, the hazard of such an investment must also be contrasted with the safety of investing money in one's own home. The reader will note that on this chart, D subtracted from C for one-inch insulation gives a net saving over a 20-year period of $557.30; for two-inch insulation, $1,007.60; and for full-thick insulation, $1159.30.

Professor Miller's figures graphically illustrate why the cost of applying insulation must be included in any legitimate discussion on the Economics of Insulation. In the case of Mineral Wool, this is particularly true because the cost of installing one square foot of three-inch insulation is not greater than the cost of installing thinner layers of the same material. This is because of the greater stability in vertical positions when placed between the studs and the greater ease of attaching the vapor barrier paper to the face of the studs.

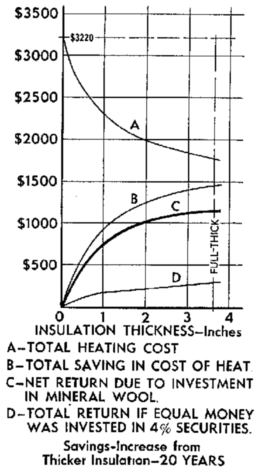


FIGURE 11

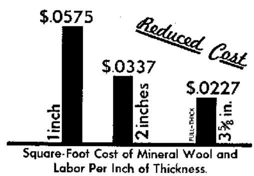


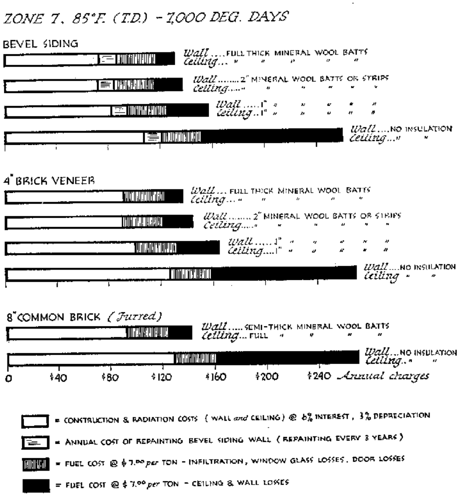
FIGURE 12

In their excellent paper, entitled, "Economics of Insulation," Professors F. B. Rowley and R. C. Jordan, of the University of Minnesota, confirm this viewpoint in developing the installation cost of insulation and assign a labor cost of 13 hours per 1000 square feet for the installation of all thicknesses of Mineral Wool batts manufactured. This equality of installation cost is generally recognized throughout the trade, so that in the comparison of added thickness, we must take into account the very great reduction in cost per inch of thickness for the various thicknesses in which Mineral Wool is produced.

An attempt by the engineers of the Mineral Wool industry to illustrate the effect of various thicknesses of insulation on construction costs, taking into consideration the cost of amortization and repainting as well as interest and depreciation, is shown in Figure 13. It will be readily seen that insulation in masonry walls is essential to bring the heating costs down to levels that correspond with those for frame construction.

Taking frame construction alone, it will be noted that the annual charges for 1000 square feet of uninsulated frame wall are in the neighborhood of $220.

FIGURE 13



Figured according to American Society of Heating and Ventilating Engineers recommended practice by National Mineral Wool Association New York City

This includes interest and amortization on cost of construction. The annual cost of the same structure with the cost of one-inch insulation added is approximately $140; with two-inch insulation, it is approximately $122; with three-inch insulation, it is approximately $119. Thus, the annual cost of owning the more comfortable wall is actually less with the thicker insulation. These estimates are based on coal at $7 per ton; with more expensive fuels, or with more expensive coal, the differentials would be even greater. In fact, some expensive fuels are often prohibitive without insulation.

ALLOWABLE BUDGET FOR HEAT

It is sometimes thought that complete insulation is justified only in the larger houses normally occupied by the higher income groups. Space does not permit an exhaustive analysis of this question, but it can be seen in Table I, which was prepared by Mr. R. K. Thulman of the Federal Housing Administration, that there must be a reduction in the budgetary allowance for heat in relation to the family income.

In this table, it is evident that in zone 5, or 5000 degree days, the family with an income of $1250 can allow only $57 for fuel, while the family with a $2000 income can allow $95. This differential, of course, is partially compensated by the fact that the $2000-income family can afford a larger house. Yet, it is also perfectly apparent that the family with the lower income must curtail, not only the size of its house but also the size of its fuel bill. For, the latter item could easily be higher than that of the higher-income family, if no insulation were included in the house of the lower-income family. This analysis and the statistics

TABLE I. Allowable annual budget in dollars for heat in millions of BTU with cost of fuel at 80¢ per million according to zone location and family income.

Zone	*$1000*	*$1250*	*$1500*	*$1750*	*$2000*
1.	35.0	44.5	54.4	64.6	75.0
2.	37.5	47.7	58.1	69.0	80.0
3.	40.0	50.8	61.9	73.3	85.0
4.	42.5	54.0	65.6	77.6	90.0
5.	45.0	57.0	69.4	82.1	95.0
6.	47.5	60.2	73.1	86.4	100.0
7.	50.0	63.3	76.9	90.8	105.0
8.	52.5	66.4	80.6	95.2	110.0
9.	55.0	69.6	84.4	99.6	115.0
10.	57.5	72.7	88.1	103.9	120.0

in Table I serve to justify the inclusion of insulation in all houses regardless of size or cost.

The cumulative effect of full-thick insulation in both walls and ceilings of a two-story house is sometimes overlooked when engineers resort to the cold figures or mathematical calculation to present this idea.

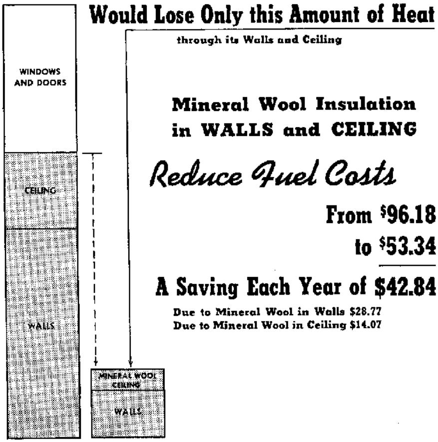


FIGURE 14

However, graphical representation of these same data, as in Figure 14, demonstrates how important it is to include both walls and ceilings in any house that is to be insulated.

In Table II is shown a recapitulation of the computations upon which the above figure is based. This analysis was developed by an independent engineer after securing cost figures in Detroit and, the savings indicated are for that heating zone. This recapitulation illustrates that substantial yearly returns are possible on an investment in insulation for either walls or ceilings.

TABLE II.

RECAPITULATION

1—Mineral Wool Insulated Walls cost[1]................$91.00
Yearly Return in Fuel Saving...........................$28.77
Wall insulation pays big returns—it should be included when the house is built but can be installed later by pneumatic process.

2—Mineral Wool Insulated Ceiling costs............$38.64
Yearly Return in Fuel Saving..........................$14.07
By all means insulate your top floor ceiling with Mineral Wool—at once if possible—but defer this investment, along with that of Storm Sash, if necessary to build Mineral Wool into the walls.

3—Storm Windows and Doors cost........................$96.00
Yearly Return in Fuel Saving..........................$16.59
By all means equip your house with Storm Sash—at once if possible—but defer this investment until later if necessary to build in Mineral Wool first.

[1] Costs of Mineral Wool and Storm Sash and Doors will vary somewhat in different localities due to material and labor costs.

EASY FINANCE AND ITS EFFECT ON THE ECONOMICS OF INSULATION

When it was necessary to make a down-payment of 50 per cent or say $70 on an extra $140 for insulating an average house in the course of construction, there was a financial handicap that has now been practically out-dated by the low down-payment facilities pioneered by the Federal Housing Administration. Now the buyer of a new house needs to put up only 10 per cent or $14 out-of-pocket for each $140 invested in insulation. (The veteran needs make no down payment.)

Under such favorable conditions, the benefits of maximum insulation are now easier to acquire than ever before, and the economics of insulation have taken a favorable turn. For, if it is possible to save $35 a year on a $140 investment, there need only be made an out-of-pocket investment of less than the savings for the first year, and the balance of the money can be placed on a long-time mortgage which has an amortization and interest charge of less than $10. Thus, we may have a net gain of about $25 the first year. Some might accept the statement that this shows over 100 per cent return on the money invested; but whether or not this is a legitimate method of figuring the returns on insulation in new homes, the fact remains that large returns are certain for a small initial extra payment.

EFFECT OF RISING FUEL COSTS

Most of the calculations given in this paper have been based upon 7-cent fuel oil and $7.75 per ton coal. There has been no increase in the price of Mineral Wool since the figures in the preceding pages were prepared. There has, however, been a slight increase in the cost for labor, but the labor cost is a very small item in relation to material cost. The net result of changes in fuel costs, therefore, will add rather than subtract from the balances discussed and illustrated.

REDECORATION

The recurrent cost of redecoration in an uninsulated house, especially on ceilings and outside walls, is difficult to assess in terms of money, but it is greatly reduced by insulation. This need for redecoration is occasioned because of uneven dust marks on the interior finish, and it is greatly reduced when the surfaces present the even temperatures obtained when insulation has been installed.

INSULATION AND MORTGAGE RATING

Earlier in this paper it was stated that the absence of insulation might cause the rejection of a mortgage. The most scientific and widely used system of mortgage rating is that developed by Frederick M. Babcock for the Federal Housing Administration, which has insured mortgages on several hundred thousand houses throughout the United States. The F.H.A. valuators do not merely examine plans and specifications or visit a house, close one eye, and say it is worth X dollars and then insure a mortgage for 90 per cent of this valuation. Instead, they have a specific system, described in their Underwriting Manual, which includes a rating of a property, a rating of the location, a rating of the borrower, and a rating of the mortgage pattern. When the sum of the credits on each of these four ratings adds up satisfactorily, the risk is acceptable. If any one of the ratings falls below the standard, the risk is not taken by the Federal Housing Administration.

Included in the rating of property are: structural soundness, resistance to elements, livability and mechanical and convenience equipment. In the rating of the borrower, we find: relation of income to transaction. In all of these tests, the problem of insulation is under consideration, for it is insulation that adds to the fire resistance in structural soundness, to the ability to heat the house properly in resistance to elements, to the comfort of the house in livability, and to the relationship of the heating plant to the heat loss in mechanical and convenience equipment.

Under the rating of the borrower, insulation is listed as a factor in the relation of income to the transaction, for if a man's heating cost is beyond his means, it is sure to cause rejection. To make this definitely a part of the record of the house, the report of the architectural inspector includes a line for insulation of the blanket, bat, or fill type, which is separated into roof or ceiling, walls, and floor (if without a heated basement). This record is also made by the valuator, who is authorized to include one hundred per cent of the reasonable cost of the above-mentioned supplementary insulation in his report; and the report of the chief underwriter requires a notation as to the presence or absence of insulation.

When the reports of these various experts are recorded, this item of insulation is given consideration in a box score, and the absence of insulation can affect the rating thus developed. This factor of the presence or absence of insulation has been in the Federal Housing Rating System since 1934, and since then, the percentage of houses including insulation has increased. It is perfectly natural that the Federal Housing Administration should want to encourage the use of insulation, because the economy, constant temperature, and comfort, both summer and winter, make for quicker resale or higher rental, and thus affect the tangible market value of the property, Furthermore, the cost of including insulation while the house is being built is definitely lower than after the house is completed. Nevertheless, the Federal Housing Administration, in its Title I for Repairs and Rehabilitation, has always promoted the use of insulation in existing houses even though it is necessary to amortize the cost in three years* instead of the usual 20 years for insulation that is installed during construction.

This question of resale value of a house is hard to get at from a dollars and cents standpoint because one of the most important elements in resale is the quickness with which a sale is consummated. Resales of satisfactory houses are usually the result of personal financial difficulty, of moving to accept a job in another location, or of similar family crises; hence, the quick salability of a property adds a definitely tangible value in considering the economics of insulation.

CONCLUSION

Perhaps this paper should be closed with the latest information as to the extent of public recognition of home insulation. This is contained in the recent survey of the Curtis Publishing Company, in which the opinion of the public as to its desires in new home construction were carefully recorded. This survey showed that 72.8 per cent of the farm families and 87.3 per cent of the urban families will demand insulation, and on the median house of about $6000 for house and lot, they are willing to invest $226 to obtain this economy and comfort. This $226 is sufficient for full-thick insulation in both walls and ceilings of a medium-sized house, and calls for an outlay of only $22.60 on a 90 per cent mortgage. The public is so well aware of this phase of the Economics of Insulation that it will only be a short-sighted builder who will offer uninsulated houses for sale in the decade ahead.

The entire United States has now experienced forced curtailment in the supplies of all types of fuel. Furthermore, because of these shortages, the government, in cooperation with industry, made fuel conservation a wartime program by publicizing it in advertising and on the radio. There is hardly a person in the country who has not experienced actual fuel curtailment or has not been indoctrinated into the necessity of winterizing through insulation and other fuel conservation devices. Nothing is such a good educator as actual experience. Thus, the recognition of insulation is on a different plane than before the war. Even agricultural authorities are giving greater weight to insulation as a means of achieving more economical production on poultry and livestock farms.

The widespread demand for insulation has caused the plants of the Mineral Wool Industry to run at maximum plant capacity for the last two and one-half years. Nevertheless, most of the companies have been so bombarded with orders that they have had to resort to voluntary allocations to customers on the basis of previous purchases.

The advent of air conditioning, in which it costs about eight times as much to lower the temperature one degree by cooling as it does to raise the temperature one degree in heating, will also have a profound effect upon the economics of insulation. The recognition of comfort and its relation to wall and ceiling temperatures is growing. An uninsulated house may soon become an unsalable house. Consequently, the economics of insulation may no longer be a question of whether one thickness or another thickness produces this or that fuel saving.

That insulation in any thickness is advantageous and that in maximum thickness it returns the greatest value for the money outlay are both contributing to a continued increase in the recognition of insulation for one or all of its economic advantages.

* A special seven-year amortization plan is available for the accommodation of veterans.

DISCUSSION

R. M. Gerhardt presiding

WHARTON CLAY: Aside from insulation for heat loss, I wish to comment that any material that is a valuable insulation against heat loss is also valuable sound insulating material. In the use of mineral wool and similar insulating materials for heat loss we also have the benefit of sound-proofing and acoustical absorption.

W. K. SHEPPARD[1]: We of the gas industry believe that insulation is economically of more value in the gas-heated home than in the home heated by coal, because we sell a relatively higher priced fuel, and consequently can secure a greater dollar saving in heating costs. Our promotional efforts in the field of home insulation have been very productive. This promotion centers around a cooperative advertising campaign, inaugurated by the gas companies in Pittsburgh, in which the insulation and storm sash dealers were invited to participate. The main burden of the expense was born by the gas companies, who contracted for a full page in the Sunday papers. The main theme of the program was in the form of publicity material and write-ups of the benefits of insulation, coupled with the Fuel Conservation Program of the U. S. Government.

Each of the insulation dealers was invited to participate to the extent of a small advertisement, which appeared on the same page as the large one of the gas companies. The results were very gratifying, as the dealers reported a marked increase in insulation sales which was largely due to the promotional efforts of the gas companies. It was generally agreed that insulation is a very important part of the gas companies' advertising and promotion of gas heating, and insulation is recommended by them wherever possible.

C. M. HUMPHREYS[2]: I do not care to enter into the discussion of this paper. The subject, as presented, is very controversial. The last paper I heard presented on this subject (by another company, incidentally) ended in heated debate. I have no desire to start that here.

W. CLAY: Slides taken from Professor Miller's presentation at the meeting Mr. Humphreys referred to were used in the present discussion. They were intended to point out that the cost of installation and cost per inch of thickness have a very definite bearing on the returns that you may expect.

T. S. SPICER[3]: I imagine that storm windows and double-paned sashes come under the general heading of insulation. More heat is lost through a glass window and around the window sash than from any other outside area of the home. The Mills rule (more commonly known as 2-20-200 rule) for estimating heating loads substantiates the last statement. The formula is based on the fact that one square foot of steam radiation will compensate for two square feet of glass or 20 square feet of ordinary wall surface. Besides the insulation advantage, storm windows also prevent sweating on the window panes. It is impossible to use a humidification system satisfactorily unless storm windows are provided for the home. From bitter experience I found that storm windows are required in bathrooms and kitchens to prevent frequent repainting of the window sills.

W. CLAY: When the government program was going on for winterizing homes, the storm sash, weather stripping and insulation people and fuel controls people—everyone connected with the industry of manufacturing fuel conserving devices—were joined together in a campaign with the government. It was also very generously entered into by gas companies in many cases, by the oil companies, and by the solid fuels people as well. The solid fuels people this year, as you probably all know, had an appropriation of $300,000 for the promotion of conservation of fuels. They had a definite campaign started, but it was discontinued just after the war was over. It would have been very valuable for the conservation of all fuels. Many people will learn by bitter experience this winter, with fuel shortages and without insulation.

DISCUSSER FROM FLOOR: I have noticed the contention that insulation in old homes causes the paint to deteriorate more rapidly.

1 Supervisor of Heating Sales, The Peoples Natural Gas Company, Pittsburgh, Pa.

2 Senior Engineer, American Society of Heating and Ventilating Engineers, Research Laboratory, Cleveland, Ohio.

3 Assistant Professor of Fuel Technology, The Pennsylvania State College.

W. CLAY: The problem of paint peeling in insulated houses is no different than paint peeling in uninsulated houses. It occurs in both.

Professor Rowley at the University of Minnesota experimented to the extent of $70,000 to determine causes of paint peeling. There doesn't seem to be a single case of paint peeling in the country that cannot be cured by understanding the problems of ventilating or high moisture.

C. H. SAWYER[4]: We have heard a little about the settling of insulation and the consequent loss of insulation value after the first year. Have you any information on this?

W. CLAY: The question of settlement of insulation is not very often brought to our attention. It can happen; only if applicators don't know much about pressure, etc.

K. C. RICHMOND[5]: What percentage of the new homes are being insulated?

W. CLAY: A survey of the Federal Housing Administration was made of 12,144 houses built from one to five years before the war. Twenty-four per cent had supplementary insulation of blanket or fill type in the ceilings and six per cent had it in walls.

K. C. RICHMOND: On Federal Loan?

W. CLAY: In a new house it goes in with the contract. That is the best answer I can give, because the figures came directly from an analysis of specifications on the use of insulation in a very large section of houses. Many were insulated later.

K. C. RICHMOND: What percentage of our 25 million single dwellings have insulation?

W. CLAY: We do not know. We think over a million. Some of the companies records are so high that the best estimate is over a million houses. That does not mean a million individual wall jobs. A million houses with ceiling or side wall. It probably means 200,000 side walls or maybe more. Those records are difficult to obtain because the insulation business in the existing house market is practically entirely in the hands of local individual applicators, heating contractors, etc. Mineral Wool production is over four times what it was before 1940.

[4] Research Division, Koppers Company, Inc., Kearny, N. J.
[5] Editor, *Coal-Heat Magazine,* Chicago, Ill.

Development of the Anthratube

By Raymond C. Johnson*

Aware that effective utilization of Anthracite depends upon the equipment which burns it, the Anthracite Industry has been assisting equipment manufacturers in the improvement of their products for almost 20 years.

An early effort to increase consumer satisfaction with Anthracite was the promotion of stokers, boilers, and similar basic equipment. The scope of this work was extended later to provide specialized service to Anthracite customers and to provide aid and educational programs for fuel dealers. The experience gathered during several years of intimate contact with problems of the consumer and the equipment manufacturers made it apparent that to obtain optimum satisfaction with Anthracite, special attention would have to be given to the equipment in which it was burned.

With this background the Anthracite industry established its laboratory which had as its prime purpose the testing, evaluation, and approval of new Anthracite burning and auxiliary equipment. This led to the development of methods of test and minimum specifications which would insure consumer satisfaction with the equipment and the fuel. At the same time the laboratory offered engineering service to manufacturers for developing new products and improving present equipment.

Upon studying different types of heating apparatus, it was obvious that there had been no major or radical improvements in solid fuel burning for many years. Therefore, several years ago the Anthracite Industry started a program of research with the objective of obtaining fundamental facts about the combustion of Anthracite. With information of this type available to engineers and designers, better equipment could be produced.

This research program has been designed to evaluate all factors that affect combustion in and heat transfer from beds of burning Anthracite. The investigation will cover the effect of size of Anthracite, bed depth, cross sectional area of bed, type of surrounding media such as air or water, and chimney size and height on the burning characteristics of the fuel. This is a long range project because of the great number of factors which influence the burning of fuels. However, from the preliminary results obtained several facts were very evident and these have been used as a basis for the design of the Anthratube.

When the various sizes of Anthracite were burned in standard boilers of 10-, 14-, and 20-inches diameter, it was found that the smaller the diameter of the boiler, the greater the percentage of heat liberated in the bed which was absorbed by the surrounding fire-pot walls. For example, with the 20-inch boiler about 35 per cent of the heat liberated was absorbed by the surrounding fire pot, while with the 14-inch boiler, 40 to 45 per cent, and with the 10-inch boiler, 50 to 55 per cent was absorbed. It appeared then that, if this increase in percentage of absorption with the decrease in diameter could be extrapolated, a satisfactory boiler could be designed in which the secondary heat absorbing surface could be eliminated. In addition the fire pot would be much smaller in diameter than those conventionally used.

Although it had previously been considered unsound to use fuel beds smaller than 12 inches in diameter because of the short attention intervals imposed and the possibility of over-cooling the bed and extinguishing the fire, the general program was extended to include a study of smaller diameter boilers. Water-jacketed fire pots of 2, 4, 5, 6, 7, and 8 inches

* Vice-President, The Anthracite Industries, Inc., Laboratories, Primos, Delaware County, Pennsylvania.

in diameter were investigated. As a result of these investigations, it was found that rice Anthracite could be burned in the 2-inch tube, whereas buckwheat and other sizes would not continue to burn due to excessive cooling of the fuel bed. The 4-inch tube gave a maximum efficiency with buckwheat Anthracite, but the output was lower than could be obtained in the same unit with pea. The 6-inch tube gave maximum efficiencies and outputs with pea Anthracite, and the 7- and 8-inch tubes gave best performance with chestnut. It was also found that the fire could be maintained at very low rates of combustion for banking.

These tests indicated that satisfactory outputs and efficiencies could be obtained with the proper combination of fuel size and fuel-bed diameter, so that it was evident that a satisfactory boiler could be designed using a small diameter fire pot. This unit should have general performance equal or superior to that of conventional boilers. It was also learned that sufficient Anthracite could be burned in the small diameter fire pots to give outputs that would produce enough heat for the average size home. The rates of combustion were much higher than those obtained in larger fire pots, but due to the smaller diameter, these high rates could be obtained without the disadvantage of the formation of clinker, a condition usually obtained at high burning rates in larger diameter fire pots.

As a result of the investigation of the fundamental properties of beds of burning Anthracite, it was shown that the thickness of the oxidation or intense burning zone in the bed depends upon the size of the fuel used. In general, it was found that Anthracite burns approximately 4 to 5 pieces deep. In other words, the oxygen in the air for combustion will pass a given amount of fuel surface before it is completely consumed. This made it possible to use the column of coal above the burning zone for heat transfer. The hot gases passing through the fuel transferred the heat to the fuel which in turn transferred it to the side walls and the heat absorbing medium. In addition, this investigation showed that the fire would not run up through the column of coal, but remained near the grate, providing the accumulated ashes were frequently or continuously removed.

The composition of the combustion gases leaving the fuel bed was found to depend upon the diameter of the fuel bed as well as the size of fuel. The greater the ratio of the perimeter of the bed to its area, the lower is the amount of carbon monoxide in the gases for any given size of fuel. This relation holds for two reasons: (1) the so-called wall effect allows a greater proportion of the air to pass along the side walls in a smaller cylinder than in a larger one, and this air allows the carbon monoxide to burn; (2) the smaller the diameter of the fuel bed, the lower the fuel bed temperature because of the close proximity of all the burning fuel to the cool side-wall surface—in general, less carbon monoxide is formed at lower temperatures.

In the preliminary experiments outputs as high as 100,000 to 120,000 Btu per hour were obtained with cylinders 6 to 8 inches in diameter. However, to obtain these outputs, a draft of 4 to 5 inches of water was necessary. This required a special induced draft fan or blower equipment which provided the required amount of air but which also produced undesirable noise. The over-all efficiencies ranged from 60 to 75 per cent which is within the range of conventional boilers.

Since these outputs and efficiencies would have been acceptable for the design of conventional domestic equipment, it was believed that a unit could be designed which should be smaller, lighter, more efficient, more convenient, and more fully automatic than any equipment now available. To attain these objectives it was also believed that the following performance specifications could be met: (1) the output should be 120,000 Btu per hour, since this would satisfy the requirements of a great majority of small homes; (2) the stack draft required for operation at the above rating should not exceed 1 inch of water; (3) the stack temperature at maximum rating should not exceed 500°F; and (4) the over-all efficiency should exceed 75 per cent.

However, as is frequently true in the practical application of theories, when the actual development of the design of the Anthratube (the name now given to the unit) was undertaken, it was necessary to make engineering compromises which deviated from the original principles. For instance, to meet the lower draft requirement it was necessary to use a relatively thin fuel bed; this increased the stack temperature, which, in turn, made it essential to add secondary heat-absorbing surface to keep within the stack temperature limitation.

Obviously, in designing a piece of equipment to meet any given specifications, there can be many different approaches to the problem. In order to benefit from as many approaches as possible and at the same time to expedite the development of the Anthratube, the work of The Anthracite Industries Laboratory has been supplemented by investigations of various designs made in the laboratories of The Delaware, Lackawanna & Western Coal Company, Pennsylvania Coal Company, and The Philadelphia and Reading Coal and Iron Company. The Anthracite Industries, Inc., has also employed Axeman-Anderson Associates, consulting engineers, to develop another version.

The work has progressed to the point that, at the present time, two different models have reached a stage of development where it is considered desirable to place a limited number of units in homes for field test. It will be essential after the laboratory tests have been completed to study the operation of these units in homes under various operating conditions when attached to different types of heating systems. One hundred and fifty installations are contemplated for the present heating season.

One of these models to undergo field tests, a magazine-feed steam or hot-water boiler which has been designed by Axeman-Anderson Associates, is shown in Figure 1. The unit occupies a floor area of 22 by 21 inches. The over-all height is 55 inches, while the bottom of the magazine door is 40 inches from the floor. The magazine holds sufficient Anthracite to burn 24 hours at maximum rate. Although the unit is shown with a magazine, an automatic bin feeder is now being developed so that the magazine can be replaced with automatic feed at some future date.

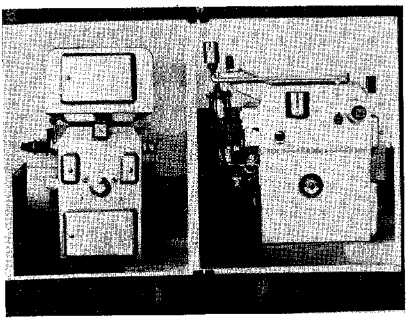


FIGURE 1. MAGAZINE-FEED ANTHRATUBE

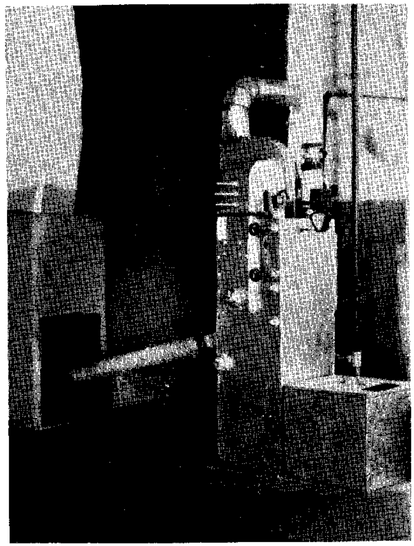


FIGURE 2. BIN-FEED ANTHRATUBE

The ashes are shaken through the grate and deposited in an ash can in the base. The grate action, which provides ash removal from the bed, is controlled by a thermostat beneath the grate so that when the ashes accumulate, the temperature beneath the grate decreases and starts the grate action. When the temperature comes up to a certain level, the action of the grate is stopped.

The draft is created by an induced draft fan which provides a draft of approximately 1 inch of water. The induced draft has several advantages: it insures a positive recovery of the fire at all times; it keeps the unit under reduced pressure which prevents the escape of gases and dust; also, the rate of operation of the unit can be varied from minimum or banked rate to maximum within 10 or 15 minutes.

The gross output of the unit is 110,000 Btu per hour, which is equivalent to 460 square feet of steam or 785 square feet of hot water radiation. The efficiency at maximum output is over 80 per cent.

The second model which is being installed in the field was developed in the Anthracite Industries Laboratory. This model, which is shown in Figure 2, and also in a cross-sectional drawing in Figure 3, differs substantially from the model shown in Figure 1. However, both models are based on the Anthratube principle.

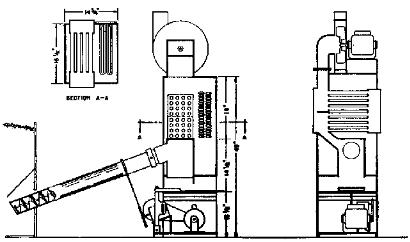


FIGURE 3. CROSS-SECTION OF BIN-FEED ANTHRATUBE

This model occupies a floor area of 16 by 15 inches and is 45 inches high. It has a gross output of approximately 120,000 Btu per hour, which is 500 square feet of steam or 800 square feet of hot water radiation. The efficiency at maximum output is well over 80 per cent.

Coal is fed from the bin to the unit through an Archimedes screw. The grate for ash removal consists of a flat plate with a ¾-inch step which reciprocates with a 2-inch stroke. The ashes are discharged through the front of the unit into a can. The ash removal is controlled by a thermostat located just above the ash discharge plate. This control turns off the motor which operates the coal feed and the reciprocating ash plate when a temperature of 190°F is reached, turning it on again when the temperature falls to approximately 180°F. If the fire were to go out, an "out fire" control operates when the temperature of the ashes reaches 130°F. This prevents feeding coal out of the bin into the ash can.

It will be noted that the fire pot is 7 by 7 inches and approximately 15 inches deep. The heat absorbing section consists of double pass, fire tubes. The induced draft fan, which will supply 1 inch of draft, may be placed on top of the unit or next to the chimney. The fan is controlled by an aquastat, a pressurestat, or a thermostat. The only control not used on conventional equipment is the ash removal thermostat. Both models also have provisions for supplying domestic service water, either by a tank heater, or by an instantaneous hot-water system.

The units which have been placed in the field are giving excellent results. They are replacing many types of equipment so that comparative operating data can be obtained.

Although only steam and hot water Anthratubes have been developed to a point where they are being installed in homes for field tests, this method of burning can also be used for direct warm air heaters. Several models are now in the laboratory and other units are being designed.

DISCUSSION

H. W. Nelson presiding

A. O. DADY[1]: I think Mr. Johnson had a very interesting and instructive piece of work in those first studies that has shown something we didn't know about Anthracite. Evidently he was surprised too.

The thing that impresses me especially is the commercial and semi-commercial development, its extreme simplicity, and I think that is one of the things which holds promise of real development. When you get something better and simpler, you stand a good chance of going places.

R. C. JOHNSON: We have other developments which will be much superior and simpler than this unit shown here. You are invited to come to the laboratory and see the development work in progress and units under operation.

With the Archimedes screw, the entire tube turns and as the coal fills to the end of the tube, feeding is stopped because the coal falls back over the screw flight. The amount the tube feeds depends on its pitch, size, type of worm, and speed. The tube on the present unit under continuous operation will feed 70 to 80 lb/hr. There is no crushing, no wear. We use a light gear reducer because there is no positive action. If we used positive type of feed it would be essential to put on a mechanism to disengage the feeder to prevent over-feeding.

D. L. GETZ[2]: Would you give more information on the Archimedes screw?

R. C. JOHNSON: We have investigated all different screw pitches. We are now using a four-inch tube with a two-inch pitch. The worm in the tube is tack-welded on one end. The Archimedes screw on the pick-up end must be inside of the tube. If it sticks out you get grinding and it takes more power.

D. L. GETZ: Is the screw of the coreless or shaft type?

R. C. JOHNSON: There is no shaft, it is just a spiral which must be close fitting.

D. L. GETZ: Do you have figures on the amount of combustible in the ash?

R. C. JOHNSON: On the units in the laboratory and in the field the combustible in the ash averages 25 to 30 per cent.

S. J. LEVINE[3]: How do you keep down the hold-fire rate?

R. C. JOHNSON: The burning rate in the unit is very low. We have maintained fires for long periods of time with an average Anthracite consumption of about ½-pound of Anthracite per hour. There are no special methods necessary in keeping the fire this low, except of course the necessity of a low draft.

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1 Chief Engineer, Stoker Division, David Bradley Mfg. Works, Bradley, Illinois.

2 Engineer, Steel Products Engineering Co., Springfield, Ohio.

3 Heating Equipment Engineering Division, Air Conditioning Department, General Electric Co., Bloomfield, N. J.

The Battelle Stoker

By R. A. Sherman*

EDITORIAL NOTE

THE DEVELOPMENT and operation of this stoker for use with various bituminous coals was shown by means of motion pictures. In the absence of Mr. Ralph A. Sherman, Supervisor of the Fuels Division, Battelle Memorial Institute, the film and development work were described by Dr. Harlan W. Nelson, Research Engineer, Battelle Memorial Institute, Columbus, Ohio.

Time-lapse motion pictures showed the operation of the stoker with different coals and its action in overcoming or combatting coke-tree formation by strongly swelling coals. No manuscript was submitted for publication.

* Supervisor, Fuels Division, Battelle Memorial Institute, Columbus, Ohio.

DISCUSSION

H. W. Nelson presiding

H. W. NELSON: That of course represents one of the many developments that are taking place in various coal research laboratories. We will see other examples a little later. I think it is encouraging to see so many. After all, one machine may not be the complete and final answer to all problems of coal utilization in residential heating.

DISCUSSER FROM FLOOR: What was the relative rate of heat output with lignite as compared with other coals?

H. W. NELSON: I don't know. It is less, due to the characteristic of the coal itself.

DISCUSSER FROM FLOOR: This stoker was automatic, I presume.

H. W. NELSON: The stoker is a bin-fed model; coal is fed automatically from the bin to the stoker and the ashes removed into a receptacle. In the present stage of the art, this would be considered completely or fully automatic.

The ash removal system wasn't shown in these movies. It is a conventional screw conveyor and receptacle type.

D. R. MITCHELL[1]: I don't see or understand how with any very low fusion coal you could have complete ash removal.

H. W. NELSON: You mean the danger of clinker formation? With low-fusion coals, the grate area is large enough so that the rate of combustion is relatively slow over the grate and, therefore, danger from the formation of clinkers which would not pass through the slots is avoided.

S. J. LEVINE[2]: I think this has been answered very well, but I like to look at it this way. You can't have clinkers unless there is an accumulation of ash and a sufficiently high temperature to fuse the ash. You can burn coal below 2000° F, and no ashes are going to clinker under those conditions.

H. W. NELSON: That is the point I tried to cover.

[1] Head, Department of Mineral Engineering, The Pennsylvania State College.

[2] Heating Equipment Engineering Division, Air Conditioning Department, General Electric Company, Bloomfield, N. J.

Bryant Coke Stoker

By C. E. Shaffer*

Domestic coke sales in this country have increased from less than one million tons in 1920 to about nine million tons in 1940. This is a remarkable selling record. Yet, as late as 1941, the last year relatively unaffected by the war, probably less than 200 tons of coke per year were burned automatically. On the other hand, during the same period equipment for other fuels had become modernized through the use of oil burners, gas burners, and coal stokers. In 1941 there were nearly two and one-half million oil burners, over one million gas burners and almost one million coal stokers, a total of about four and one-half million automatic heating units in the United States. It has been estimated from Bureau of Census statistics that in 1940 around 24 per cent of all centrally heated dwellings (those with boilers or furnaces) were heated automatically. Thus, about one-fourth of the possible potential market for hand-fired fuels in centrally heated dwellings has already been changed to automatic heat.

Domestic coke producers have long been aware of this trend toward automatic heating, and have been experimenting for years on devices to burn coke automatically. When this experimentation was begun, the stoker market was first surveyed thoroughly to find whether there was any existing equipment which would burn coke automatically, with the result that a number of stokers of various kinds were bought for trial. But, not one was found that was entirely satisfactory for coke. Consequently, it was necessary for the Koppers Company to initiate a stoker development program. The work was conducted for several years with many different types of stokers until finally, one was developed which was believed to be good enough for the market. However, since the Koppers Company did not wish to manufacture the coke stoker, its manufacture was licensed to The Bryant Heater Company of Cleveland, manufacturers of gas burners and appliances. Production had barely started when the war began. As a result, only about 250 units had been built and installed, most of these in 1941, when the manufacturer was forced to stop building stokers.

The Bryant Coke Stoker as originally built (see Figure 1) was completely automatic and of the conversion type, which means that it could be adapted to existing types of central heating plants. It consisted of a plunger-type underfeed stoker, a grate, a full-sized bin and an ash-removal system; a one-sixth horsepower motor-reducer furnished sufficient power to drive the unit. The bin had two sloping sides in the form of a V, and in the bottom of the V, a sheet metal conveyor which extended to the stoker. Coke was moved along a reciprocating flat plate in the conveyor from the bin to the stoker. In the stoker proper, coke was moved on another plate conveyor to the

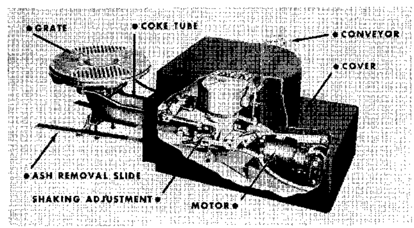

FIGURE 1. EARLY MODEL

* Research Division, Koppers Company, Inc., Pittsburgh 19, Pennsylvania.

elbow of the stoker where it was pushed upward into the firepot by a plunger attached to the end of the plate conveyor. An oscillating, circular flat grate, made of alloy iron, was fitted around and supported by the elbow in the center of the retort. Ash was removed from the ash pit by means of two reciprocating steel strips, which were really small plate conveyors, one on either side of the coke tube. The ashes were dropped into cans set in the floor adjacent to the boiler.

Stoker control was independent of combustion control; it consisted of a counter-balanced weight which rested on the top of the fuel bed and was attached to a rod that extended out through the fire-door frame. The rod actuated a switch which, as the fuel bed rose or fell, either started or stopped the stoker motor according to the need for fuel. Thus, regardless of whether the combustion rate was low, as with a banked fire, or high, as on a zero day, the stoker control maintained a constant level of fuel in the firepot. Combustion control or control of burning rate, on the other hand, was effected by means of a room thermostat which actuated a conventional type of damper motor. Since the stoker was operated with natural draft, no blower or induced draft fan was necessary.

For a new piece of equipment in its first year of manufacture, the original Bryant Coke Stoker performed remarkably well. Mechanical failures were infrequent with the exception of a number of failures of the flat, alloy iron grates. As a consequence of these grate failures a new grate was designed which was

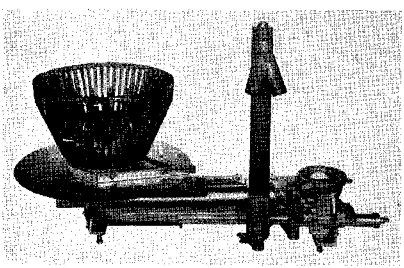

FIGURE 2. STOKER WITH INCLINED GRATE

used to replace most of the original grates. The new grate (see Figure 2) consisted of roughly pie-shaped segments with square ends installed in the form of an inverted (truncated) cone, the small end of which rested on the edge of the open end of the elbow at the center of the retort, while the large end leaned against the walls of the firepot. Although the segments were stationary, there was sufficient agitation of the fuel bed by the stoker plunger to cause the ash to sift down through the fuel bed, through the slots in the grate and into the ashpit. The stoker, therefore, was simplified because no grate-shaking mechanism was required for the new grate. Furthermore, since the steeply inclined grate segments "faced" the cool boiler walls, they were cooled by radiation as well as by convection (and conduction). This cooler grate has permitted the use of ordinary cast iron, instead of alloys, in its construction, yet no instances of burned-out grates have been reported during the two years which this type has been in use. In addition, clinkers and overheating are rare with the new grate.

The reaction of the owners of the Bryant Coke Stoker has been exceptionally favorable; even those who had trouble with the original grate would not consider having their stoker removed. One of the most common observations, especially by those who formerly had oil burners, has been with regard to the "evenness of the heat" from the coke stoker. The reason for this is that, although the stoker runs intermittently, combustion in the fuel bed is continuous, with the result that the heat is more even and comfortable than with the usual intermittent type of oil or gas burner. "Cold 70," often obtained with on-off type of burners, has not been experienced by any of the 250 owners of coke stokers.

During the past year the Bryant Heater Company has redesigned and streamlined the original stoker for the post-war market. The experience gained as a result of having 250 stokers in use for three to four years has been invaluable as a guide for this work. The new stoker has a hydraulic drive, a belt conveyor from the bin, an above-the-floor ash removal system (see Figure 3), stationary grates as described above, and all of the other desirable features of the original model. The new model (see Figure 4) is more compact than the early one and it has been streamlined for greater eye appeal as well as utility.

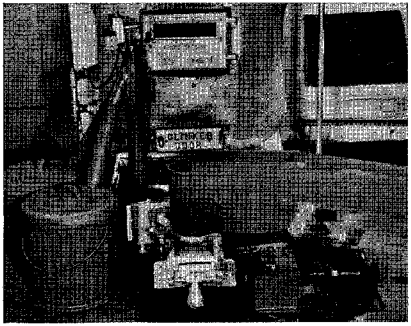

FIGURE 3. NEW STOKER WITH COVER OFF

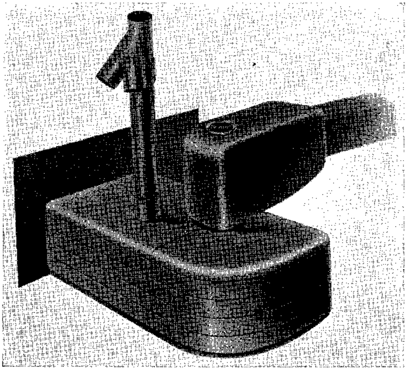

FIGURE 4. NEW STOKER WITH COVER ON

In conclusion, it is believed that the Bryant Coke Stoker, as described in this paper, will provide a completely automatic means of heating dwellings with coke. The author, however, does not presume that this or any other coke stoker will solve all domestic coke sales problems in the future, or make coke as easy to sell in the future as it was during the war. Nevertheless, further developments in and the wider adoption of automatic heating methods will continue in the future, and an automatic coke stoker will be a valuable aid to the domestic coke manufacturer in meeting competition in the automatic heating market.

DISCUSSION

H. W. Nelson presiding

C. E. LESHER[1]: I have a few questions. How high an ash content can be handled by the inclined grate?

C. E. SHAFFER: With this grate we can handle coke up to about 10 to 12 per cent ash. However, we prefer a coke made from pulverized coal so that the ash is finely divided. Most domestic cokes are now made from pulverized coal.

C. E. LESHER: If you are working with lower fusion than 2500°F, might you get into trouble?

C. E. SHAFFER: I don't know what the exact lower limit of ash fusion is with this grate, but we have handled cokes with 2350° F ash fusion temperature. The fuel bed in the inclined grate is cooler than ordinary fuel beds and we get less clinker. However, we insist that the boiler or furnace

[1] President, Pittsburgh Coal Carbonization Co., Pittsburgh, Pa.

be large enough for the house or we will not install the stoker.

C. E. LESHER: Have you an upper limit on coke size?

C. E. SHAFFER: Yes. We like to burn regular domestic sizes up to about two-inch top size. We don't like too small a size.

C. E. LESHER: If you had enough of these installed and had sufficient market, would you be willing to crush all coke?

C. E. SHAFFER: That is a future problem. At present we can handle most of the regular sizes without further preparation. In the future we might revise the stoker to take all sizes now regularly produced in domestic coke plants.

D. R. MITCHELL[2]: We have been talking about size, top and bottom, but no one has specifically stated what size is best for this stoker. What size do you recommend?

C. E. SHAFFER: As in hand-firing, the size of the coke depends on the size of the boiler. If the boiler is small, I would say "range" (3/4 x 1-1/4 inch or thereabouts); if the boiler is medium or large, we would recommend "nut" (approximately 1-1/4 x 2-inch).

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[2] Head, Department of Mineral Engineering, The Pennsylvania State College.

The Pennsylvania Stoker

By C. C. Wright*

INTRODUCTION

Bituminous coal stokers have been marketed in many localities for many years. Some of these units have given the home-owner a certain degree of trouble-free performance not previously attainable by hand-firing methods, but from the viewpoint of the home-owner and the coal producer, none of these units has attained the degree of automatic performance available with liquid or gaseous fuels. With one exception, even the degree of automatic performance possible with bin-feed ash-removal stokers available for anthracite has not been available to the user of bituminous coal. Moreover, in the leading coal-producing states of the East, most if not all the bituminous coal stokers have failed to give satisfactory combustion performance when burning the strongly coking coals which constitute all but a small fraction of the normal tonnage.

The latest available statistics on the number of stokers per unit of population are shown by states in Figure 1, and it is significant to note that the states leading the list are those where relatively free-burning coals are readily available, whereas the two leading bituminous coal producing states of the Union, West Virginia and Pennsylvania, as well as the states where their coals are principally marketed, are well toward the bottom of the list.

As a research organization interested in the efficient utilization of Pennsylvania's primary resources, the Mineral Industries Experiment Station made a survey of the use of Pennsylvania coals in particular, and of bituminous coal in general, as a fuel for the completely automatic heating of the home. It was immediately apparent from this survey that in order for bituminous coal to attain a truly competitive position in the domestic heating field, the industry was faced with a number of problems, among the most significant of which were:

1. Elimination or control of coke-tree formation and the various difficulties resulting directly or indirectly therefrom.
2. Elimination or control of dust and dirt, including fly-ash, resulting from coal handling and burning.
3. Improvement of automatic performance, including feeding of the coal, removal of the ashes and control of firing.
4. Elimination of mechanical troubles associated directly or indirectly with the stoker, the controls, the heat recovery equipment and their installation.

From the technical viewpoint it would appear that none of these problems is insurmountable, although from the economic viewpoint the practicality of the solutions evolved might be questioned on the basis of existing knowledge. However, as has been well demonstrated by the phenomenal growth of the radio, refrigerator, and numerous other industries, progress is not made by assuming that an objective cannot be attained simply because the economics appear unfavorable at the time; new knowledge and new developments frequently change attitudes and viewpoints quite rapidly.

With these considerations in mind, the Commonwealth of Pennsylvania in cooperation with the Bituminous Coal Industry of Pennsylvania has sponsored at the Mineral Industries Experiment Station an extensive program of research on Comfort Heating with bituminous coal. One of the developments of

* Chief, Division of Fuel Technology, The Pennsylvania State College.

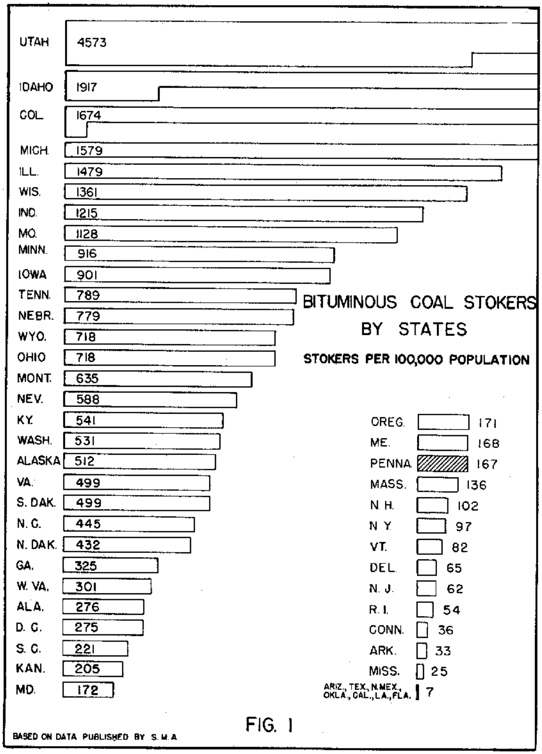


FIG. 1

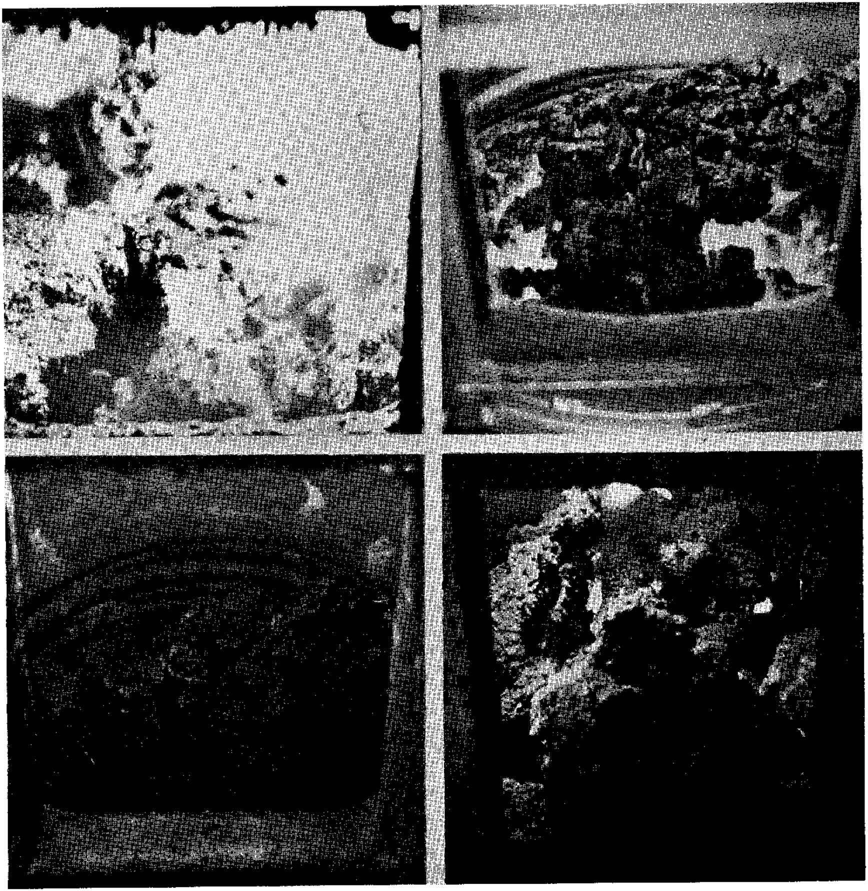
this program has been the Pennsylvania Stoker which, although not by any means the complete and final answer to all the problems of comfort heating with bituminous coal, is believed to be a definite step toward this objective.

RESEARCH AND DEVELOPMENT

The initial phase of the research program was made up of laboratory and field studies on the performance of a number of popular makes of stokers. The results of this work suggested that a solution of the problem of coke-free formation was essential before any intelligent attack could be made on the other problems associated with fully automatic domestic heating with bituminous coal, such as ash removal, control of fly-ash and hold-fire control. Figure 2 shows a few types of coke-trees that may be encountered when burning strongly coking bituminous coals in ordinary domestic installations; it is obvious that where such conditions arise there is little hope of fully automatic operation, or even of heating performance acceptable to any but the most tolerant home-owner.

It was recognized that several ways existed by which coke-tree formation could be eliminated; two examples are: (1) the use of less strongly coking coals and (2) the processing of the strongly coking coals to reduce their coking tendencies. Fortunately, simple and inexpensive means of influencing the type and structure of the coke produced from bituminous coals are known to fuel technology.

For example, it is well known that the coking tendencies of coal are markedly reduced if not destroyed when coal is mildly oxidized, as by weathering under atmospheric conditions. Furthermore, in the laboratory, this destruction of coking properties can be made to occur much more rapidly at somewhat elevated temperatures. This method is illustrated by Figures 3 and 4 and by the data of Table 1. Figure 3 shows the effect on the coking properties, as measured by the British Standard Crucible Swelling test, of oxidizing samples of 10-mesh coal with air at 428°F for increasing lengths of time. The rate at which oxidation occurs as a function of temperature is illustrated



A. Pittsburgh seam ½" x o slack coal

B. Lower Kittanning seam 1¼" x ¼" stoker coal

C. Upper Freeport seam ½" x o slack coal

D. Thick Freeport seam ⅜" x o slack coal

FIGURE 2. FUEL BEDS IN CONVENTIONAL STOKER BURNING STRONGLY COKING COALS

in Figure 4, taken from the work of Parr. Although this work was based on Illinois coals, the principle revealed is applicable to coals of higher rank; in general, however, the temperatures required are somewhat higher the higher the rank of the coal.

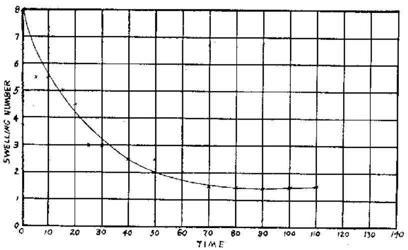


FIGURE 3. EFFECT OF CONTROLLED AIR OXIDATION ON THE SWELLING NUMBER OF A STRONGLY COKING BITUMINOUS COAL

The phenomenon of coal oxidation appears to be primarily one of surface attack as is shown by the data presented in Table 1. These data demonstrate

TABLE 1. Effect of Oxidation on the Swelling Properties of Various Size Fractions of a ½-in. by 0 Coal Sample.

Time of Oxidation (minutes) *Size Fraction*	*0*	*5*	*10*	*15*	*20*
	Swelling Number				
½" x 60-mesh Fraction[1]	6.5	6.5	6.5	6.5	6.5
60 x 100-mesh Fraction	6.5	6.0	6.0	5.0	3.0
Minus 100-mesh Fraction	6.5	6.0	6.0	4.5	2.5

[1] Pulverized to minus 60-mesh after oxidation, before determining Swelling Number.

the change in coking index, as measured by the British Standard Crucible Swelling test, of the various size fractions of a sample of ½-in. by 0 bituminous coal oxidized for different times at 428°F. It is evident that no significant effect on the swelling number is detectable until the size of the oxidized fraction approaches that of the coal size, namely, 60-mesh, used for the Crucible Swelling test. That is, the coarse-coal fraction must be pulverized after oxidation before its Swelling No. can be determined, whereas the Swelling Nos. of the two fine-coal fractions can be determined without further size reduction. Consequently, it appears that in the former the surface oxidation film is destroyed with the result that the coal behaves as fresh coal. In the latter, on the contrary, coalescence of the particles and subsequent swelling of the coal are reduced because the surface oxidation film surrounding each coal particle is unbroken. Thus, the coalescence of coal particles to form coke is influenced in part by surface conditions and not directly by the swelling index of the coal (which is ground to 60-mesh size for the swelling test); therefore, it may be expected that the effectiveness of the oxidation treatment will be substantially the same irrespective of coal size, providing the surface film of oxidized coal is intact.

COAL OXIDATION VS. TEMPERATURE

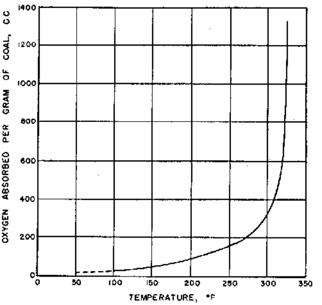


FIGURE 4

From the foregoing, it would appear that the control of coke-tree formation could be accomplished readily by a mild oxidation of the coal before it enters the plastic state. This should be possible by introducing a portion of the total air required for combustion into the coal in a zone of the stoker retort in which the coal is heated, but has not yet entered the plastic state. Preliminary experiments indicated that this could be done by introducing the required air a few inches below the level of the primary air tuyeres where, because the heat in the castings is conducted downward into the retort, the coal is heated, but has not yet attained the temperature of plasticity. For the sake of simplicity the air for oxidation, called "preoxidation air" to differentiate it from the primary oxidation or combustion air, was introduced into the coal feed tube through an enlarged smoke-back. Adequate contact between air and coal was achieved by means of a vertical screw in the retort which also served to elevate the coal. In addition, the vertical screw produced uniform distribution of coal in the retort and reduced degradation of the coal.

The essential features of the preoxidation design as disclosed in U. S. Pat. No. 2,378,805 (June 19, 1945) are shown in Figure 5 which shows the air introduced

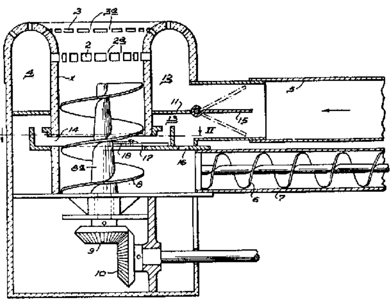


FIGURE 5. SCHEMATIC VIEW OF DESIGN PRINCIPLE OF PENNSYLVANIA STOKER FOR ELIMINATION OF COKE-TREE FORMATION. PRIMARY TUYERE PORTS ARE REPRESENTED BY NOS. 2 AND 3, AND PREOXIDATION TUYERE PORT BY NO. 14. PROPORTIONING OF THE AIR BETWEEN PREOXIDATION AND PRIMARY TUYERE IS ACCOMPLISHED BY DAMPER NO. 15. ELIMINATION OF SEGREGATION AND REDUCTION OF DEGRADATION OF COAL, AND MIXING OF COAL AND PREOXIDATION AIR IS ACCOMPLISHED BY MEANS OF THE VERTICAL SCREW—NO. 8.

through an auxiliary tuyere in the retort of the stoker. For most coking coals it has been found that 15-30 per cent of the total air introduced at this point is sufficient to eliminate coke-tree formation; however, with oil-treated coals somewhat more may be required because of the protective influence of the oil film. The air is introduced into a zone where the coal is not heated and is mixed intimately with the coal as the latter passes up through a zone of increasing temperature. As a result the coal is oxidized before becoming plastic; hence, upon subsequent carbonization in the zones of higher temperatures, the coke produced is friable and breaks under its own weight into lumps of a size ideal for combustion. The light, porous coke formed by this method is much more reactive than the dense, hard coke-trees frequently formed in stokers and, therefore, the fuel bed is more responsive to control.

Figure 6 shows coke-buttons from the British Standard Crucible Swelling test on four series of samples taken from the retort of a stoker modified to incorporate the preoxidation principle. Sampling ports 1 and 2 (not shown) are below the level of the preoxidation tuyere. Port 4 is substantially at the level of the preoxidation tuyere and ports 4, 3, 5, 6, and 7 are spaced approximately one inch above each other. Port 8 is approximately ½" above port 7 and is at the level of the primary tuyere. Table 2 shows the operating conditions under which Tests A, D, E, and F, illustrated in Figure 6, were obtained.

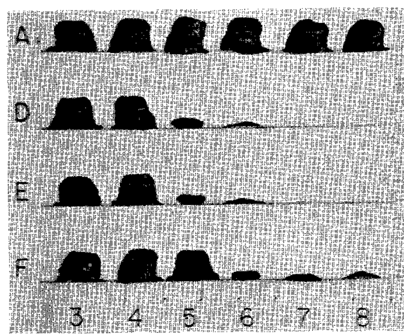


FIGURE 6. EFFECT OF PREOXIDATION ON SWELLING PROPERTIES OF UPPER FREEPORT ½" X 0 SLACK COAL

Table 3 shows the temperatures of the coal at ports 1 to 6 inclusive and were secured in two independent tests in which the stoker was operating on a 45-minute ON, 15-minute OFF cycle. The measurements were

TABLE 2. Effect of Preoxidation on Swelling Properties of Upper Freeport ½-in. by 0 Slack Coal

Condition of Tests

Series	Type of Operation	Rate of Feed, lb per hr	Air Entering	Condition of Bed
A	Continuous	10	Primary tuyeres only	Medium size coke tree
D	Continuous	20	Preoxidation and primary tuyeres	Level bed, no coke tree
E	Continuous	20	Preoxidation and primary tuyeres	Level bed, no coke tree
F	Continuous	20	Preoxidation and primary tuyeres	No coke tree, level bed 4 in. above tuyeres

taken at the end of the third 45-minute ON period and indicate that the preoxidation phenomenon occurs at relatively low temperatures.

The effect of introducing or not introducing pre-

TABLE 3. Temperatures in Retort

Sample Port No.	Coal Temperature °F			
	Lower Kittanning ¾-in. by 0		Pittsburgh Seam 1¼-in. by ⅜-in.	
	Near Retort Center	Near Retort Wall	Near Retort Center	Near Retort Wall
1	97	82	97	86
2	129	104	111	100
4	126	113	122	108
3	151	117	147	122
5	356	203	239	172
6	662	371	239	169

oxidation air is illustrated by the fuel-bed pictures shown in Figure 7 using 1-in. by 0 Lower Freeport seam coal and Lower Kittanning ¾-in. by 0 coal. The legend is self-explanatory. For these tests the coal feed and total air setting were held constant, but the proportion of air between primary and preoxidation tuyeres was varied as indicated. The vertical screw was in operation during both tests.

Three different makes of stokers, including a manual, dry ash-removal type, an automatic ash-removal type and a clinker-removal type, were modified to incorporate the preoxidation principle and were subjected to laboratory test. The modified automatic ash removal unit was also subjected to home test for two heating seasons using a variety of strongly coking slack coals. From the combustion viewpoint excellent results were attained in all the tests although minor mechanical difficulties were experienced due to the limitations of converting existing equipment.

COMMERCIAL DEVELOPMENT

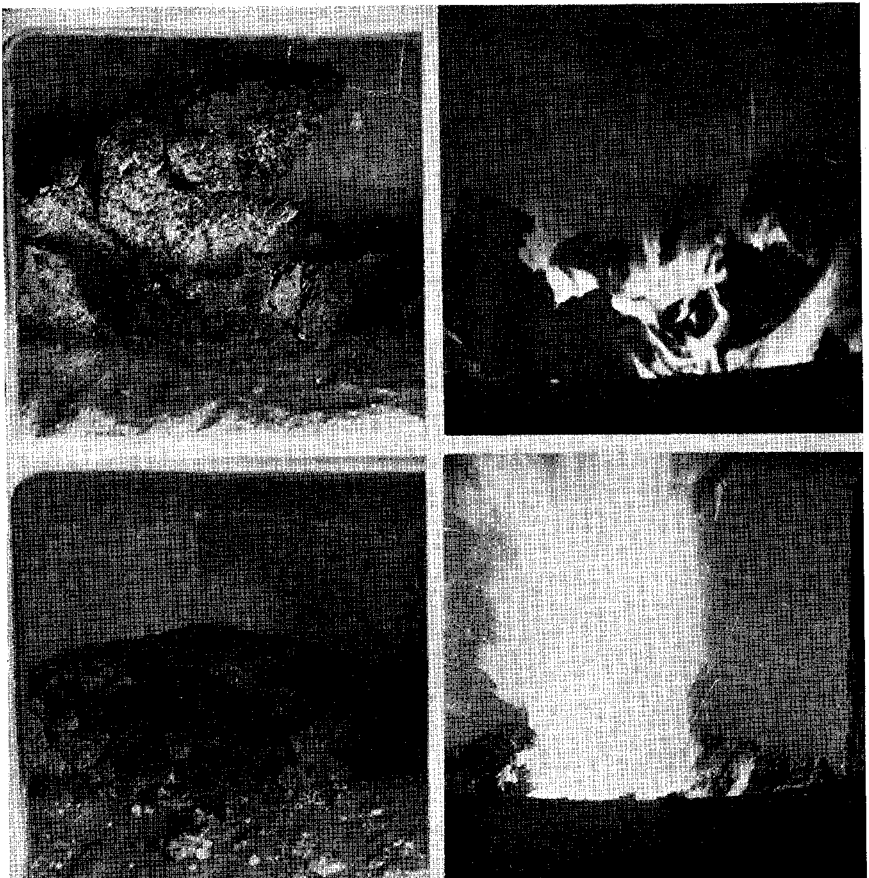
As a result of extensive laboratory and home tests on modifications of conventional stokers, a complete, new design was developed by an organization interested in the application of this principle to domestic stokers. The new stoker is known as the "Pennsylvania Stoker." Several preliminary models were developed and subjected to careful laboratory test. As imperfections were found the design was changed until the current model was developed. Under the supervision of the Stoker Research Staff, two of these units are under test in the Stoker Laboratory and five were tested in homes throughout the State during the past heating season. Several units were also tested in laboratory and home installations by the manufacturer. A hopper-feed model of the "Pennsylvania Stoker" is illustrated in Figure 8. The first units of this stoker incorporated automatic ash removal, but not automatic bin-feed. It is hoped that later models will incorporate some form of bin-feed equipment.

Laboratory tests on the present model indicate that the unit can burn satisfactorily a wide variety of sized and slack coal without coke-tree formation. With some of the most strongly coking coal in the slack sizes, the fuel beds were not perfect; nevertheless, satisfactory operation was obtained. The following summarizes a few typical test results:

(1) *Pittsburgh seam coal,* 1-in. by 0 slack, A.S.T. 2240°F; Feed rate, 27 lb/hr.

Fuel bed good on cycle operation, good on hold-fire.
Clinker formation—none.
Refuse—clean.
Fly-ash—normal.
Hold-fire rate[1]—1.5 lb/hr.
Average CO_2— (ON periods, 10-14%; OFF periods, 6-8%)

[1] All hold-fire rates herein reported were obtained using a temperature-actuated stack type hold-fire control. Using a temperature-actuated firebox type hold-fire control, hold-fire rates 50-75 per cent lower than these values have been obtained in prolonged laboratory tests.



A. Lower Kittanning ¾" x 0 coal; Excess air, 50 per cent; Cycle, 2 min ON–6 min OFF

B. Coal, total air, and cycle as in (A), but with about 25 per cent of total air to preoxidation tuyeres

C. Upper Freeport 1" x 0 coal; Excess air, 50 per cent; Cycle 2 min ON–6 min OFF

D. Coal, total air and cycle as in (C), but with about 30 per cent of total air to preoxidation tuyeres

FIGURE 7. FUEL BEDS IN PENNSYLVANIA STOKER; WITHOUT PREOXIDATION AIR IN (A AND C); WITH PREOXIDATION AIR IN (B AND D)

(2) *Lower Kittanning seam coal,* 1-in. by 0 slack, A.S.T. 2430°F; Feed rate, 27 lb/hr.

Fuel bed heavy and ragged on cycle, but coke friable; good on hold-fire.

Clinker formation—few small marbles.

Refuse—satisfactory.

Fly-ash—excessive.

Hold-fire rate—1.3 lb/hr.

Average CO_2—(ON periods, 14%; OFF periods, 8%)

(3) *Upper Freeport* ½- by ¼-in. stoker coal, A.S.T. 2360°F; Feed rate, 21 lb/hr.

Fuel bed fair on cycle with friable coke; fair on hold-fire.

Clinker formation—none.

Refuse—fair.

Fly-ash—normal.

Hold-fire rate—2.3 lb/hr.

Average CO_2—(ON periods, 11%; OFF periods, 6%)

(4) *Lower Freeport seam coal,* 1-in. by 0 slack, A.S.T. 2470°F; Feed rate, 19 lb/hr.

Fuel bed—good on cycle; good on hold-fire.

Clinker formation—5% of ash released.

Refuse—fair (70.4% ash)

Fly-ash—excessive (1% of coal fed)

Hold-fire rate—1.5 lb/hr. (est.)

Average CO_2—(ON periods, 12%; OFF periods, 7%)

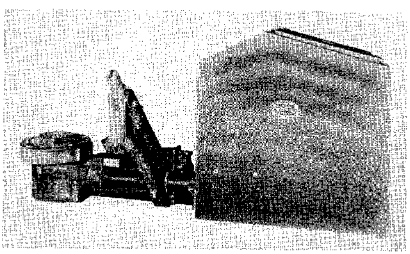


FIGURE 8. SIDE VIEW OF HOPPER MODEL SHOWING LIFT-UP TYPE ASH REMOVAL

The reports on the home tests of the five units in the field may be summarized as follows:

HOME NO. 1 GRAVITY AIR FURNACE

Coals burned: Pittsburgh seam, ⅜- by ⅛-in., ¾- by ⅜-in., 1-⅜- by ⅛-in. and 1-in. by 0
V.M.=36% A.S.T.=2400 to 2100°F

Combustion Performance: After modifications and adjustments during the first few months, no coke-tree formation observed even with slack coal. House well heated. Coal consumption lower than in previous years.

Hold-fire: A few outfires and some overheating during mild weather, attributable in part to controls and in part to gravity system.

Clinkers: Some clinkers formed during severe weather, but none after final modification of tuyere design late in February.

Refuse: Ashes reasonably satisfactory (69% ash or better for all four tests).

Smoke and Fly-ash: Light smoke evident in firebox at times, but no smoke at stack. Fly-ash collected in furnace, radiator and smokepipe and chimney.

HOME NO. 2 FORCED AIR FURNACE

Coals burned: Thick Freeport seam, 1- by ⅜-in. and 1-in. by 0
V.M.=33-34% A.S.T.=2300-2400°F

Combustion Performance: No coke-tree formation observed with the sized coal at any time, but ragged fuel bed and some friable coke-trees reported when using slack. Coal consumption 20 per cent lower than for average of previous several years when using another stoker.

Hold-fire: No difficulties with outfires or overshooting.

Clinkers: Excessive clinker formation (substantial percentage of total ash) during severe weather which, after a check of installation, was found to be due largely to carrying too low a percentage of excess air and too low fires (CO_2, 16-19% during the ON periods). No clinkers produced after necessary adjustments to about 50 per cent excess air.

Refuse: Fair after elimination of clinker troubles.

Smoke and Fly-ash: Some light smoke evident in firebox but not at stack. Fly-ash not objectionable although periodic removal from furnace radiator necessary.

HOME NO. 3 GRAVITY HOT WATER SYSTEM

Coals burned: Upper Freeport 3/4- by 1/4-in., 3/4- by 3/8-in. and 3/4-in. by 0
V.M.=33% A.S.T.=2250-2600°F

Combustion Performance: No coke-tree formation and excellent beds with sized coal. Some coke-tree formation at high feed rate (27 lb/hr) when using the slack coal, but none at medium (19 lb/hr) or low feed (13 lb/hr) rate. Coal consumption about 25 per cent less than previous years' average on hand-firing.

Hold-fire: Some overheating was reported during mild weather attributable largely to excessive overfire draft (no positive draft control used on this installation) and to gravity water system.

Clinkers: Excessive clinkers with original tuyeres and grates; eliminated after modified design installed.

Refuse: Good after elimination of clinker trouble.

Smoke and Fly-ash: No smoke in firebox or at stack. Fly-ash no problem.

HOME NO. 4 GRAVITY HOT WATER SYSTEM

Coal burned: Lower Kittanning, 3/4- by 1/4-in. and 3/4-in. by 0
V.M.=21-22% A.S.T.=2200-2300°F

Combustion Performance: Excellent with both sized and slack coal. Coal consumption reported as substantially lower than normal.

Hold-fire: No overheating, except when fly-ash collected on stack control and prevented normal operation.

Clinkers: Some clinkers removed by hand prior to change of tuyere design, during cold weather estimated as 10 per cent of ash released. After change of tuyere design no clinker troubles experienced.

Refuse: Clean during winter operation, some fine carbon loss during mild weather.

Smoke and Fly-ash: No smoke at firebox or stack. Fly-ash trap installed with this unit and collected fly material amounting to 0.33 per cent of coal fed.

HOME NO. 5 GRAVITY HOT WATER SYSTEM

Coal burned: A. Lower Kittanning 3/4- by 3/8-in.;
V.M.=23% A.S.T.=2450°F
B. Lower Freeport 3/4- by 3/8-in.;
V.M.=18-19% A.S.T.=2600-2700°F

Combustion Performance: Very satisfactory during entire heating season.

Hold Fire: No overheating.

Clinkers: With coal A, 2.8 per cent by weight of coal fired; with coal B, insignificant amount. Most of coal A was burned with the original tuyere and grate design but some clinker also formed with improved design.

Refuse: Satisfactory, except that oversized bone and slate in coal A tended to plug grates and prevent proper ash removal unless grates were manually cleaned periodically.

Smoke and Fly-ash: No smoke at firebox or stack. Fly-ash trap installed with this unit and collected 6.6 bushels, or 0.64 per cent by weight of the coal fed.

Home installation and laboratory tests on a variety of coals from Pennsylvania, Maryland, West Virginia, and Kansas have also been made by the manufacturer, who reports that no difficulties have been experienced from coke-tree formation when burning any of these coals in either double-screened or slack sizes. With the low ash-fusion Kansas coals, some difficulties were experienced from clinker formation when using the original tuyeres, but modification of tuyere and grate design is reported to have eliminated even this difficulty.

It was the belief of several people who saw the early models of this stoker that difficulty would be experienced from burning off the tip of the vertical screw, or from the coal burning back into the retort during off-periods. Neither of these difficulties have been experienced. In the laboratory one ordinary cast iron screw has operated under a variety of conditions for a period of time equivalent to about 3 years of operation in the home and is still in serviceable condition. The only screw tips so far destroyed in either laboratory or home tests have been caused by operating the stoker without feeding coal. With respect to the coal burning back into the retort during long hold-fire periods, especially when using free-burning coals, the use of the vertical screw appears to be advantageous. Because of the presence of the vertical screw, the heat is carried away more rapidly and the coal in the lower part of the retort is kept cooler; hence, there is less tendency for the ignition level to creep downward in the retort.

As a result of the laboratory and field tests during the past year, some minor modifications in retort and grate design have been made with a view to simplifying the servicing and assembly of the stoker and to eliminating difficulties encountered in automatic ash removal. Further tests on the latest model are planned for the coming heating season before the unit is finally released for general distribution.

DISCUSSION

H. W. Nelson presiding

C. S. BRENNER[1]: I have been burning ⅜- by 1-in. coal on the test model Pennsylvania Stoker installed in my home about a year ago, and I can absolutely control the coke trees with this size coal. In addition, I can get excellent hold-fire operation, and maintain low room temperature. I also burned some 1-in. by 0 coal of the same type and the coke tree was eliminated almost entirely as long as I operated more or less continuously with the thermostat calling for heat a reasonable proportion of the time. However, in hold-fire operation in mild weather, the 1-in. by 0 coal did produce some coke trees.

C. C. WRIGHT: These gentlemen have had field models in their homes for a year. Mr. Davis of the Pittsburgh Coal Company—you have been burning Pittsburgh seam coal, ⅜- by ⅛-in., most of the time and part of the time ⅜-in. by 0 slack, which in conventional stokers is highly coking. Would you care to offer any comment on your experience?

D. H. DAVIS[2]: Coke trees have been eliminated to such an extent that strongly coking coals can be successfully burned by the Pennsylvania Stoker. Some clinkers are formed when burning Pittsburgh ⅜- by ⅛- in. of 2350°F A.S.T., particularly when operating on hold-fire for several days with a very thin fuel bed. Usually these clinkers are about ½ to 4 inches in size and are too large to be handled by the ash-removal mechanism. By making a little coke, clinkering of the ash can be practically eliminated. In severe temperatures the best operation is obtained by forming a friable coke which breaks up of its own accord and forms a fuel bed of coke. Little or no formation of clinkers occurs with this method of operation even with a coal of 2200° F A.S.T. With the Pittsburgh seam ⅜- by ⅛-in. coal, ash removal has been satisfactory, although clinkers must be removed once or twice a month. In mild weather it is possible to operate with a low fuel bed, and in my installation the coal consumption on hold-fire is approximately 1.5 pounds per hour.

C. C. WRIGHT: Of the six test stokers in homes only two have caused any trouble from either burned tuyeres or burned screw tips. Mr. Brenner's stoker was operating for awhile with a deficiency of air and a too high percentage of CO_2, and a set of tuyeres was burned out. Mr. Weismann's unit burned a screw tip as a result of operating without coal being fed. In the laboratory we have had no serious trouble

[1] Sales Manager, Butler Consolidated Coal Co., Wildwood, Pennsylvania.

[2] Product Control Manager, Pittsburgh Coal Co., Library, Pennsylvania.

with tuyeres. They are cast iron. We have not used any alloy metal at all.

P. L. GROSS[3]: We have received a liberal education in some of the coal fields. We also have common troubles I believe. The question comes to my mind, when you break up the coke tree do you increase the fly ash?

C. C. WRIGHT: No. In fact there seems to be a tendency to reduce it. When you have coke trees such as you saw in the picture that Dr. Nelson showed of the conventional stoker where you have a large coke mass in the center, you are putting all the air around the periphery of the coke tree, and tend to blow fly ash off the surface of the coke as it burns.

We have fly ash data on two of the homes where Pennsylvania stokers were used last year. Using double-screened coal in the Pennsylvania Stoker, the fly ash was approximately 0.3 to 0.5 per cent of the total coal fed; and for the conventional stoker, using double-screened coal, it ran about 0.5 to 0.7 per cent. Using slack coal, the fly ash was 0.7 per cent from the Pennsylvania Stoker, and 0.9 to 1.2 per cent in tests on an O-P Ash-removal Stoker. We feel that we have adequate proof that the Pennsylvania Stoker with the level fuel bed gives less fly-ash trouble than does the conventional stoker in which large coke trees or coke masses are formed.

C. C. RUSSELL[4]: I am curious about the oxidation of the coal. A few years ago we were interested in producing non-coking coal from a coking coal. The coal was pulverized to minus 20-mesh, put into a rotating drum and heated to approximately 400°F in a regulated stream of air. Under those conditions it took something over an hour to oxidize the coal until it was non-coking. In this stoker you have coal of half-inch average size in contact with a very small amount of air a matter of very few seconds until it is apparently non-coking. Why does this oxidation happen so rapidly in the stoker when we have found, both in the laboratory and in large scale work, that much more severe conditions are required to produce non-coking coal from coking coal?

C. C. WRIGHT: The question is answered to some extent in the paper. Data not presented during my oral presentation are shown which indicate the phenomenon is largely one of surface oxidation. The coke-tree forming tendencies of a coal in the stoker can be changed without destroying the coking tendency of the coal as a whole. This is illustrated by some oxidation tests on ½-in. by 0 slack coal in a rotary furnace. After 20 minutes the swelling number of a sample ground to minus 60-mesh to conform to the standard test was unchanged, but the swelling number of the 60 x 100-mesh and minus 100-mesh fractions of the sample were markedly decreased.

C. E. LESHER[5]: I recall an observation we made in connection with test work on low-temperature carbonization. We put a charge in a test retort and gave it pre-oxidation treatment between 600°-700°F. By test against commercial units we obtained certain results in the size and character of coke. Now if we tumble that around for a longer time, the effect is different. We have some reason to believe that if we shut off the air, lower the temperature, roll the stuff around and then try to coke it, the same result is not possible, because that surface oxidation film rubs off. We have had no occasion to make use of this observation, but I remember it turned up in some research work.

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[3] Coal-O-Matic Stoker Company, Trucksville, Pennsylvania.

[4] Research Division, Koppers Company, Inc., Kearny, New Jersey.

[5] President, Pittsburgh Coal Carbonization Co., Pittsburgh, Pa.

Advances in Heating Equipment—Stove and Space Heaters

By J. C. Miles *

IT SEEMS logical that one should approach this problem by considering the requirements for an "ideal" or perfect stove, just as one would approach the problem of engine analysis by first considering the ideal cycle, and then comparing actual performance with the ideal; therefore, it is pertinent to list the requirements of this "ideal" stove.

1. Time between firings—infinity
2. Control—perfect
3. Efficiency—100 per cent
4. Smoke emitted—none
5. Type of fuel—any
6. Cleanliness—absolute
7. Ash removal—never
8. Energy emitted—radiant
9. Appearance—beautiful
10. Useful life—forever
11. Space required—none
12. Cost—nothing

The writer proposes that we think in terms of *what has been done* and what *can be done* to approach this perfect model. At the outset, he would state that, although this paper was supposed to deal with anthracite as well as bituminous coal, he does not feel adequately qualified to discuss the former, except in a general way, for the work at Illinois has dealt solely with bituminous coal, since that state has an abundance of soft coal, but has no hard coal.

The problems encountered in burning anthracite domestically are much simpler than those of burning bituminous coal. Moreover, the Anthracite Industry has long had a research program for studying its problems, whereas the Bituminous Coal Industry is just getting well under way. As a result of this situation, anthracite is shipped half way across the United States to such places as St. Louis where, at half the price, there is perfectly good soft coal just across the river. Still, the bituminous industry has no satisfactory way of burning its product domestically except in mechanical stokers.

Although many people regard stoves as obsolete and outmoded, and they consider research on stoves as a waste of time, the use of stoves can be justified to some degree. These same people think of stokers and central heating systems as the ideal way to burn coal, and one would heartily agree with them. However, they have forgotten (1) that there are many people, in this the world's richest country, who feel that they cannot afford a stoker, or (2) that there are many people who prefer to buy other things instead. To illustrate the importance of stoves, let us consider the number of families which are using them as indicated in Table I, based on statistics of the 1940 U. S. Housing Census. It can be seen that nearly 16 million heating stoves are used in the United States; this large number of stove users may be divided into two general groups:

(1) A group of people who would convert to modern centralized heating equipment if their dwelling had been originally designed for it, and providing electricity were available for stoker drive. For this group the best in stoves would be desirable.

(2) A larger group who, for economic reasons, do not feel justified in investing in modern centralized heating equipment. From this group there is a demand for stoves ranging in price and perfection from the cheapest possible to the very best.

At least one car will be owned by practically every family in each of the above groups; but, there will still be the matter of "relative worth," which makes a car more desirable than a centralized heating system

* Assistant Professor of Mechanical Engineering, University of Illinois, Urbana, Ill.

to those who cannot afford both, even though the car costs more.

Indications are that progress in stoves and space heaters will not be marked by a single deluxe design which everyone will adopt, but rather by certain fundamental improvements that can be applied to all stoves throughout the entire price range. As evidence for this belief, one need only examine the prewar catalogues of the large mail order companies which manufacture and sell many stoves; it is interesting to note that the price range begins at 98 cents. Some of the more expensive designs, ranging up to $65 in price, more nearly conform to the specifications of an ideal stove. Presumably, the majority of the 16,000,000 American stoves now in use are of the type falling in the low-price range; some postwar stoves, however, are being built to sell at $150.

Let us consider what progress has been made in the past several years toward the ideal stove by considering the extent to which the requirements, in the order given, are being met.

1. FIRING PERIOD. With "infinity" as the desired time interval between firing, we note the wide public acceptance that certain magazine stoves have enjoyed, largely because they can hold enough coal to stay warm until morning. Such stoves have a capacity of around 100 pounds per charge and represent a big step in the right direction. If they have to be fired once a day that is a lot nearer the ideal than five times a day, as some stoves require. Furthermore, it means that the dirt incidental to refiring and the labor involved are about one-fifth as much, and even more important, the stove will stay warm 24 hours or longer. A great many stove builders are working on some form of magazine stove to meet this very desirable feature.

2. CONTROLS. These have long been considered essential to the central heating system, but have not been considered necessary for a stove or space heater, particularly when the cost of the control or regulator was $20 and the stove had to sell for $10. In this case a 30-cent cross damper had to be enough. Lately, barometric and thermostatic draft regulators have appeared on the better models. However, this phase of the stove and space heater problem is largely unexplored and constitutes a fertile field for research and development. Moreover, it is being realized that the use or design of tight-fitting ash and fire doors is essential to proper control and long hold-fire under banked conditions.

3. EFFICIENCY. One cause of low efficiency in the old style stove resulted from stack loss through excess air and consequent low carbon dioxide. The inlet air damper opening was generally much larger than necessary, which resulted in over-control and stack gas dilution. Some magazine-type stoves are marked by the opposite characteristic. In the magazine stove with up-draft burning, its operation is essentially equivalent to a very deep fuel bed. Consequently, with all the air admitted at the bottom, the stove runs radically short of secondary air during part of the cycle, particularly after the charge has been thoroughly heated. This results in losses in the form of carbon monoxide and some unburned hydrocarbons; however, both of these conditions could be corrected with a reasonable study of air requirements. In some designs lack of radiator capacity is largely overcome by relying on the stove pipe to serve as radiator.

4. SMOKE EMITTED. The ideal stove would never produce smoke under any circumstances. It is, therefore, a rather rare design; nevertheless, research will doubtless produce a stove approaching this ideal. Since the stove industry is characterized, in general, by a large number of small, independent companies, most of them with only limited research facilities, the recent pooling of endeavors for stove research at Battelle Memorial Institute is to be commended; it will surely yield results. The author does not know what stage of development this work is in, for he has seen no official technical release; this is logical since the technical results should go to those companies subscribing to the project.

Concerning the work that is being done at the University of Illinois, several illustrations have been prepared to show what progress has been made. The work has been largely an application of the Down-Draft Coking Method of burning soft coal, conceived by Professor J. R. Fellows. Since 1939 the writer has been concerned with the application of the method to boilers, stoves, and water heaters. Meanwhile, Professor Fellows has been largely concerned with the warm air furnace and stove applications. This method of burning soft coal is illustrated in Figure 1,

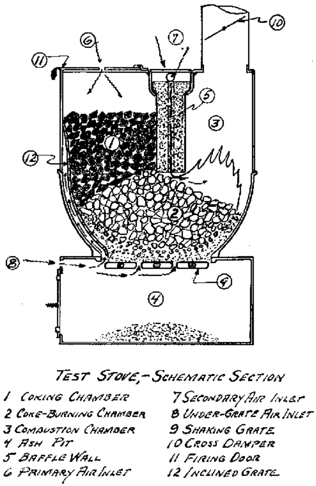

FIGURE 1

which is a vertical section of a model built in 1940 and tested quite extensively. The burning process consists of driving the gases from a charge of green coal (1) placed in a coking oven. The gases can escape only by passing over a deposit of hot coke (2) that has been left from a previous charge. The coke is kept hot by undergrate air (8) that passes through it. The rate of distillation of the green coal is largely dependent on, and therefore controlled by, the amount of primary air (6) passing through it. Secondary air (7) to complete the oxidation is brought to a point where it is mixed with the volatile gases in the hot region.

Several designs and methods of application have been made. Figure 2 shows a vertical section of a model that is now under test. So far, nothing can be found wrong with this design, either from the performance angle or from the construction angle. This model has a diameter of 16 inches and is 3 feet high; it holds 70 pounds of coal and has a by-pass attached to the firing door, which is in the rear. Since all the air enters at one point, it is adaptable to thermostatic control. The refractory is of simple, dry-pressed shapes. This model will burn small nut coal at the rate of 5 pounds per hour, with 0.05-inch draft, and it has been banked for as long as four days. Although no claim is made that this unit will never smoke under any circumstances as in the case of the ideal stove, it does not smoke with any Illinois coal where a minimum of care is exercised. A very clean and colorful

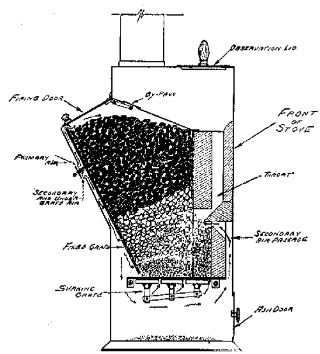

FIGURE 2

flame is obtained in the throat of the stove. In Figure 3 a shop model of this design is shown. Figure 4 shows the Down-Draft Coking Method applied to a small water heater.

5. TYPE OF FUEL (COAL SIZE AND KIND). Stoves are capable of burning a wider variety of coal than most other equipment, particularly stokers and industrial equipment. The coal sizing and processing that is necessary for these latter uses leave a wide size choice available for stove use.

TABLE I. OCCUPIED DWELLING UNITS BY HEATING EQUIPMENT, FOR THE UNITED STATES, BY REGIONS, URBAN AND RURAL: 1940*

Area and heating equipment	Total		Urban		Rural—nonfarm		Rural—farm	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
UNITED STATES								
All occupied units	34,854,532	......	20,596,500	......	7,151,473	......	7,106,559	......
Reported heating equipment	34,144,370	100.0	20,187,387	100.0	7,002,905	100.0	6,954,078	100.0
With central heating	14,343,633	42.0	11,746,736	58.2	1,892,797	27.0	704,100	10.1
Steam or hot-water system	7,424,844	21.7	6,616,433	32.8	669,185	9.6	139,226	2.0
Piped warm-air system	5,725,273	16.8	4,472,656	22.2	877,856	12.5	374,761	5.4
Pipeless warm-air furnace	1,193,516	3.5	657,647	3.3	345,756	4.9	190,113	2.7
Without central heating	19,800,737	58.0	8,440,651	41.8	5,110,108	73.0	6,249,978	89.9
Heating stove	15,926,928	46.6	7,081,423	35.1	4,286,115	61.2	4,559,390	65.6
Other or none	3,873,809	11.3	1,359,228	6.7	823,993	11.8	1,690,588	24.3
Not reporting heating equipment	710,162	......	409,113	......	148,568	......	152,481	......

* United States Bureau of the Census 1940. Census of Housing.

6. CLEANLINESS. This topic is one that the bituminous coal people do not adequately appreciate. (The Anthracite Industry is blessed with a cleaner product.) With bituminous coal the problem of cleanliness is one of the factors that will enable clean competitive fuels to gradually displace coal in the domestic field. For use in stoves or space heaters that are normally installed in the "parlor" on the carpet, a *really clean* form of soft coal is needed. To the writer's knowledge there is only one absolutely clean form of soft coal, and that is packaged coal—not necessarily briquetted, but placed in 10- or 20-pound manila paper bags, which can be sealed and fired in that fashion along with the fines. (More could be said; ask any housewife who uses soft coal.)

7. ASH REMOVAL. Second to the coal, if not *first* as a producer of dirt, are the ashes. The prestige of coal stoves would go up 1000 per cent if one never had to remove the ashes. The next best thing to "never" is as infrequently as possible, and with the least disturbance possible. Ash pans have long been used, but generally they have to be small and shallow, and must be emptied frequently. In addition, they require juggling to pass through the ash door. Assuming that a larger ash tray would be desirable, Figure 5 shows an ash tray made of stainless steel or aluminum. It serves as the bottom of the stove below the grate line, because it replaces the conventional stove bottom, ash door, and door frame. It is tight-fitting, easily removed, large, and light, and is installed from the rear of the heater; the ashes are not disturbed on removal. A second tray is also necessary as a spare. But what woman is there who couldn't use a spare pan of this type? For equipment other than stoves, an ash pit big enough to hold a whole season's ash accumulation, and built directly under the unit is the only logical way to make ash removal automatic.

8. ENERGY EMITTED. There is no warmth quite so soothing and pleasant as that radiating from an open fireplace, provided one is within a comfortable range to receive it. If such radi-

ant energy could be adequately controlled and directed to all parts of the house, it would produce ideal conditions; however, realization of such an arrangement appears highly improbable. Instead, the convection type of circulating heater offers a partial solution to the problem of heat distribution within the house of limited size. To accelerate the circulation of warm air some late designs of stoves are equipped with fans to produce forced circulation over the unit. Good possibilities exist for a low-cost heating system consisting of a stove placed in a central utility room through which air is forced or led by natural circulation to adjacent rooms.

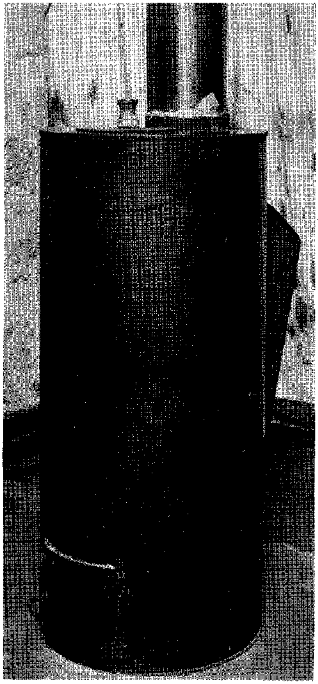

FIGURE 3. SHOP MODEL OF STOVE EMPLOYING DOWN-DRAFT COKING METHOD

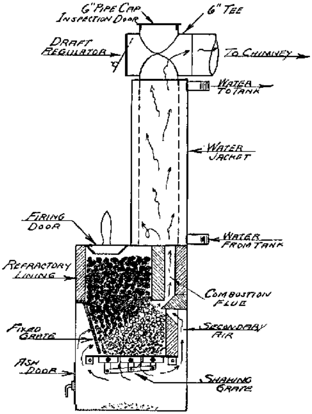

FIGURE 4.

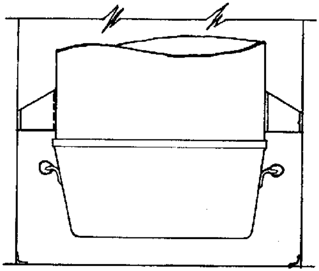

FIGURE 5. ASH PAN FOR CIRCULATING HEATER

9. APPEARANCE. It is not probable that stove designers will ever produce a thing of beauty and a joy forever, but some large strides have been made in dressing up the typical stove to a point where it at least appears to be a modern piece of furniture with an attractive finish, capable of being cleaned externally.

10. USEFUL LIFE. This factor is largely a function of the quality and quantity of materials built into the unit and, therefore, may be dismissed as a function of initial cost.

11. SPACE REQUIRED. The modern stove design provides a maximum of coal capacity for a minimum of space required in contrast to the large decorative cast-iron units of former years. It is not probable that any further improvement can be made in this feature.

12. COST. Stoves will continue to be the lowest cost form of heating equipment, and as such they will serve the millions of families in the low-income brackets. Stoves will continue to be built over a wide price range to meet the demand of families in all the ranges of low income. The designs will range from the simplest form of unlined sheet metal units to the highly finished magazine type of circulating heater, and cost will be comparable to value received.

DISCUSSION

Henry F. Hebley presiding

H. N. OSTBORG[1]: Professor Miles is to be complimented on his fine paper describing the progress of work on smokeless heaters at the University of Illinois. All concerned with space heaters of that type know the intense work that has been done in their development, but I should like to express my belief that the domestic market is not completely ready for a smokeless heater, as the general public will continue to buy by appearance and price until stringent city smoke ordinances are widely recognized and adopted. In order to improve a coal heater to the point where it becomes smoke-free in operation, increased cost is usually involved; and, because the average buyer of heaters belongs to the lower income brackets, he usually has to consider the purchase carefully before spending thirty or forty dollars for a heater.

I have seen many types and designs of coal heaters, and have been rather surprised and disappointed in some of the manufacturing techniques employed. The accepted attitude has been to sell by external appearance rather than by soundly engineered products. I believe that one of the prime things that the coal industry can do for the stove industry would be to draw up a set of "ten commandments" for good manufacturing practice. One, and probably the first, should be to build them tight. Too many heaters are simply thrown together with improper sealing and poorly fitting dampers and doors.

The point that I should like to emphasize is that even though we realize the need for advancement in coal-fired space heaters, I don't believe that we should overlook the fact that at the present time we have a major problem with most of the existing heaters on the market and those to be produced within the next few years.

E. R. KAISER[2]: I think we certainly owe a debt of gratitude to Professors Fellows and Miles of the University of Illinois in developing a

[1] Testing Engineer, Merchandise Testing and Development Laboratory, Sears, Roebuck & Co., Chicago 7, Illinois.

[2] Assistant Director of Research, Bituminous Coal Research, Inc., Pittsburgh 22, Pa.

smokeless principle that could be applied both to stoves and furnaces. They started before Bituminous Coal Research, Inc. began its stove program at Battelle. They are solving the problem in one way; Battelle is solving the problem in a different way. There may be still other possibilities.

Professor Miles is correct that the BCR stove is being tried in a few field models this winter. That does not mean that the laboratory work is finished. There are still several problems that have to be solved.

I would like to ask Professor Miles how much success he has had with the strongly coking coals? I know he has done a fine job with the more freely burning types, but since stoves made even in Illinois are shipped east and those built in the East are shipped west, the customers will burn different types of coal.

I wish Professor Miles would discuss the use of coking coals and what sizes of coal he has found best suited to the stove?

J. C. MILES: We have used the hardest coking coal in Illinois. It works entirely satisfactory. The Pittsburgh extremely hard-coking coal has not been tried. The tendency with hard-coking coal is that the burning rate tends to drop off as the hours pass, for the coal seals off the air flow. In order to increase output it is necessary to open a hole through the charge to let air in. This is not difficult with the right type of poker.

We have been using nut size, $1\frac{1}{2}$- by 2-in. in this model. In the first model all types of coal were used—anthracite, lignite, free-burning, and hard-coking.

Furnaces and Boilers

By L. N. Hunter*

THIS DISCUSSION will be restricted to recent advances in the design of boilers and furnaces without reference to the heating systems with which they are to be used. There is, however, considerable work being done in improving the design of various heating systems and the means of controlling them. Since the terms "furnace" and "boiler" are sometimes used to designate a wide variety of equipment, our comments will be limited to furnaces and boilers used with central heating systems only.

CONSTRUCTION OF FURNACES

Warm air furnaces are made of cast iron or are of steel plate construction. Because of the nature of the service to which most boilers and furnaces are subjected, and because of the cost, it is unlikely that nonferrous materials will be extensively used in their construction within the near future. The heating element in cast iron furnaces is usually made in a number of parts which are assembled into a single unit. In steel furnaces, the heating element is usually made of welded, or welded and riveted steel plate. There seems to be a tendency, however, to get away from riveting in favor of all-welded construction.

Furnaces are made in many different designs but the most popular by far is the ordinary round furnace consisting of a firebox to which is attached a radiator which acts as secondary heating surface. Furnaces are used mostly to heat relatively small buildings, such as residences, and there are very few sizes made for buildings having heat losses of over 200,000 Btu per hour.

* Vice-President in Charge of Research, The National Radiator Company, Johnstown, Pennsylvania.

TRENDS IN THE DESIGN OF FURNACES

Engineering design in the furnace industry is progressive and there are a number of trends that are noticeable. Cast iron furnaces have represented the majority of all furnaces sold in the past, but steel furnaces are increasing in popularity each year; however, it is unlikely that steel furnaces will replace cast iron altogether. Nevertheless, the current trend will probably continue because of the difficulty of getting labor to work in foundries and because improvements in methods of welding steel furnaces will eventually be reflected in the cost of the furnaces.

Probably the most important advance the warm air furnace industry has made is in the development of what is called the winter air-conditioning unit. This unit consists of a furnace equipped with a motor-driven blower, a filter and a humidifier. The winter air-conditioning unit is used more extensively with automatically-fired heating systems than with hand-fired systems. The blower provides for positive circulation of the air and permits the use of a filter, which could not otherwise be used because there is considerable resistance to the flow of air through it that cannot very well be overcome by gravity circulation. Filters should be examined frequently and replaced before too much dirt collects on them; otherwise, the dirt will interfere with the circulation of the air through the system. There is considerable work being done to improve the operation of filters and some of the filters that are being developed will be somewhat different from those commonly used before the war. There is also some work being done on equipment to sterilize the air by means of lamps or chemicals.

Humidifiers are used rather extensively on both gravity- and forced-air furnaces with varying degrees of effectiveness. Many of the humidifiers that have been used in the past have not done much of a job of humidification, and those that have humidified have frequently overhumidified because of the lack of proper controls.

Another noticeable change that is taking place in furnace design is a trend towards smaller, more compact furnaces for better insulated homes which, because of the insulation, require smaller furnaces, and for smaller homes where space is at a premium. These furnaces are for either forced air or gravity circulation and for different fuels and methods of firing.

The industry is making considerable progress in the development of furnaces for automatic firing. Provisions are being made in conventional designs for easier installation of automatic burners and there are a great many furnaces being designed exclusively for certain fuels, especially for oil firing and for gas firing. Many furnaces are being designed as complete furnace-burner units in which the equipment is furnished complete with furnace, burner, controls, combustion chamber, etc. This gives a better coordination of design and usually results in a better installation. A number of furnace manufacturers are developing small, hand-fired, smokeless furnaces and one or two manufacturers are working on magazine furnaces.

WARM AIR FURNACE RATINGS

For many years there was no standard, acceptable method of determining ratings of warm air furnaces nor was there a standard nomenclature for ratings throughout the industry, and consequently, there was considerable misunderstanding and confusion on the subject. The National Warm Air Heating and Air Conditioning Association, in cooperation with the University of Illinois, developed and published in 1922, the Standard Gravity Code for the Design and Installation of Gravity Warm Air Heating Systems. This Code has been revised frequently, the latest edition, which is the eleventh, being issued in June of 1940. This Code covers entire heating systems but portions of it deal with the rating of hand-fired gravity furnaces. The Code rates these furnaces according to an empirical formula involving the grate area and heating surface; this formula was developed after testing many typical furnaces in the laboratory at the University of Illinois.

Since 1927 furnaces designed for gas have been rated in accordance with the American Standard Approval Requirements for Central Heating Gas Appliances developed by the American Gas Association. This Code requires that the furnaces be tested and rated on the basis of test performance. The Code also covers many features of construction.

Within the last two years there have been issued by the Bureau of Standards two other rating Codes for furnaces, one known as Commercial Standard CS-104-43 for Warm Air Furnaces Equipped with Vaporizing Pot Type Burners and the other Commercial Standard CS-109-44 for Solid Fuel Burning Forced Air Furnaces Having Bonnet Capacities up to 80,000 Btu per hour. Both of these Codes require testing the furnaces to determine their ratings.

The National Warm Air Heating and Air Conditioning Association has prepared a Code for testing oil-fired, forced-air units, but I believe this is still in tentative form. The Association is also giving consideration to methods of rating hand-fired, forced air furnaces having bonnet capacities in excess of 80,000 Btu per hour, to rating hand-fired furnaces convertible to stoker, oil or gas firing, and to stoker-fired furnaces.

Furnace ratings have been expressed in terms of "square inches of leader pipe" or in Btu per hour. The industry has as its objective the expressing of all ratings in terms of Btu per hour only and the showing of two ratings for each furnace, namely, the Bonnet Capacity and the Register Delivery. The Bonnet Capacity is the Btu per hour available in the air at the furnace bonnet outlet. The Register Delivery is the Btu per hour available in the air as it leaves the warm air registers. The Register Delivery on forced-air systems is assumed to be 15% less and on gravity systems 25 per cent less than the Bonnet Capacity.

CONSTRUCTION OF BOILERS

Boilers are made of assembled cast iron cored sections or of welded steel plate with steel tubes fabricated as a single unit. A number of years ago steel boilers were frequently riveted, but this method of construction is used today only for high pressure steel boilers, few of which are used for heating purposes only. Cast iron boilers are more extensively used than steel boilers, but the latter seem to be increasing in popularity.

Cast iron boilers are built in sizes having capacities of approximately 200 to 10,000 square feet of steam rating. This means they are suitable for buildings having heat losses ranging from 50,000 Btu per hour to 2,500,000 Btu per hour. There are a few cast iron boilers built in larger sizes. Steel boilers are built at present in sizes for buildings having heat losses of 65,000 to 10,000,000 Btu per hour. They are built in much larger sizes than are cast iron boilers.

Most heating boilers, both cast iron and steel, are designed to comply with the Rules for the Construction of Low Pressure Heating Boilers of the American Society of Mechanical Engineers. The primary object of this Code is safety. It has been in use for approximately 30 years and in many states and municipalities the law requires that boilers installed within their boundaries comply with this Code.

TRENDS IN THE DESIGN OF BOILERS

There are a number of improvements taking place in the design of heating boilers. One noticeable trend in design is towards smaller hand- and automatically-fired boilers for better insulated homes and for smaller homes. These smaller boilers are less costly and are more compact, so as to require less space than the ones previously used in similar sizes of homes.

There is also a definite trend towards automatic firing and the design of boilers for automatic firing. Some boilers are designed especially for certain fuels while others are designed for convertibility. They are not only readily convertible from one fuel or type of firing to another, but they also have a good efficiency and perform satisfactorily with all fuels, including hand- or stoker-fired coal, and oil or gas.

The convertible feature appeals to the public for a number of reasons. One reason is the possible shortage or interruption in the supply of the fuel the home owner might be using, in which case he can readily switch a convertible boiler to another fuel at a minimum of cost. Also, the owner may want to change from one type of firing to another, possibly because of a change in the economic status of the fuel, or in his own economic status. For example, he may be hand firing and want to change to stoker firing to obtain the benefits of automatic heating.

The feature of convertibility should be of interest to the coal producers and to stoker manufacturers because boilers that are designed especially for oil or gas are seldom readily convertible to stoker firing, whereas, those designed for hand or stoker firing usually can be converted to oil or gas firing, although it is true that the performance is sometimes not very good unless the boiler was originally designed for convertibility.

Another advantage of convertibility is that boilers can be installed in new homes without the firing equipment, and then the purchaser of the home can select any type of firing equipment he chooses. This should work to the advantage of the stoker people because usually the builder, if he installs automatic heating, puts in gas or oil and some of the prospects, if they had their choice, would prefer stokers.

There is a trend toward the use of boiler-burner units for automatic firing where the boiler is furnished complete with the burner, controls, combustion chamber, etc.; this permits a better coordination of design and generally results in a more satisfactory installation.

DOMESTIC WATER HEATING

Another important development that has been taking place in heating boilers over a period of the last several years is the application of the built-in water heater. This heater consists of copper surface usually in the form of a coil or loop submerged in the water of the heating boiler, and is used to heat the domestic hot water by the exchange of heat between the hot water in the boiler and the water passing through the coil. It is applicable to steam or hot-water systems, and by the application of the proper controls to the system, the boiler can be operated to heat domestic water throughout the year without transmitting heat to the living quarters of the house when heat is not needed. These heaters are usually available in different capacities and may be of the storage or the instantaneous type. In the near future we shall see further improvements and refinements in the design and application of these heaters to boilers and a wider application of their use because, in spite of some of the controversy there has been in the past as to the advisability of heating hot water this way, the evidence gained by experience is very favorable.

SMOKELESS BOILERS

A review of boiler design would not be complete without some reference to smokeless combustion. There were a great many hand-fired, smokeless boilers sold about 25 or 30 years ago, but the popularity of these boilers has decreased until today very few of them are sold. The sales were confined mostly to boilers having over a thousand square feet of steam rating, and therefore, they were not extensively used in residences. These boilers lost their popularity for the following reasons: (1) the performance depended to a great extent upon the skill of the operator and for that reason they were frequently not smokeless; (2) automatic firing became popular for larger boilers; and (3) smoke ordinances seldom permitted the use of these boilers, possibly because their performance depended upon the skill of the operator.

Because of the current trend in the development and enforcement of smoke ordinances, it is desirable that smokeless equipment be used in all installations, including those in residences. There is, however, a difference of opinion as to the kind of equipment that should be developed. Some feel that smokeless, hand-fired equipment is desirable, while others believe that the best way to eliminate coal smoke is by the use of a stoker-fired, standard boiler. The argument in favor of the standard boiler with a stoker is that when a hand-fired, smokeless boiler is designed, the features which have to be provided in order to make the boiler smokeless add considerably to the cost of the boiler in the form of additional weight or special sections, and this additional expense would go a long way toward paying for a stoker which would permit automatic temperature control and also give a number of other desirable features.

RATING OF BOILERS

Probably the most important development in boilers in recent years has been the progress that has been made in the methods of rating them. There has been a lack of confidence in boiler ratings and considerable confusion and misunderstanding as to what the ratings have meant. The reason for this was the lack of a common method of rating boilers and of a nomenclature for boiler ratings that was acceptable and commonly used by the industry.

The ratings for boilers designed for gas have probably given the least trouble because since 1927 they have been rated in accordance with a Code developed by the American Gas Association which is known as American Standard Approval Requirements for Central Heating Gas Appliances. The boilers are tested in the laboratory and the ratings are determined on the basis of the tests.

In 1929, the Steel Heating Boiler Institute (now known as the Steel Boiler Institute) representing the steel boiler industry, adopted a Rating Code for steel heating boilers. This Code has been revised from time to time, with the latest revision being that of June 1945. The Code has established a sound basis for rating steel heating boilers and has been widely used by the industry. It has been responsible for eliminating much of the confusion with respect to ratings that continued to exist on cast iron boilers during the 1930's. The meanings of the ratings, however, are not as well understood as they should be.

The SBI Rating Code rates larger steel boilers, which are commonly known as commercial sizes, on the basis of the amount of heating surface the boiler contains, provided the boiler meets certain other limitations including a minimum amount of grate area, furnace volume and furnace height. Although the rating of any product on the basis of physical dimensions is usually not so desirable as the rating by test, it seems to have worked out very satisfactorily with large steel boilers, probably because there is not a wide variety of designs found in large steel boilers and because the ratings permitted by the Code are conservative.

Residential sizes of steel boilers for automatic firing are rated on the basis of heating surface, but the boilers must be tested and must conform with a number of limiting factors to justify their ratings. Some of these factors are: limits for stack temperature, efficiency, draft loss through the boiler, and furnace volume. Residential, hand-fired steel boilers are rated on physical dimensions based on the amount of heating surface, grate area, and firebox volume which they contain.

The Steel Boiler Institute several years ago put into effect a simplification of boiler sizes for commercial steel boilers which limits the number of sizes to 19. Before this simplification was put into effect, manufacturers, for competitive reasons, tried to make every size their competitors made, which meant a multiplicity of sizes and inefficient production. The latest issue of the SBI Code also contains a simplification of sizes of residential, oil-fired steel boilers which limits the number of sizes to 13.

In 1939, the Institute of Boiler and Radiator Manufacturers issued the I=B=R Testing and Rating Code which has been widely adopted for rating cast iron boilers. The Code has been revised from time to time and the latest edition is that of July 1945. This Code has gone a long way toward clarifying the rating situation for cast iron boilers. It is applicable to all sizes of hand-fired and automatically fired boilers. When it was first put into effect, the manufacturers limited its application to boilers of less than 20 inches grate width. After a couple of years, its use was extended to boilers up to 41 inches grate width. The war interfered with its application to larger boilers, but the manufacturers are now completing tests on their larger boilers and, consequently, in the near future most cast iron boilers will be rated in accordance with I=B=R Code.

The I=B=R Code requires that boilers be tested and the rating be established on the basis of the test results. Hand-fired boilers must be tested on a given stack height the selection of which, within certain limits, is left up to the manufacturer; hence, a low draft loss through the boiler is important. The greater the draft loss the greater the height of chimney required. The boiler must meet specifications as to the time the available fuel will last; therefore, adequate firebox volume is essential. There is also a minimum efficiency specified, and a limitation on the percentage of moisture permissible in the steam.

Ratings for automatically fired boilers are determined by testing the boilers with oil. These tests are run at a fixed percentage of CO_2 and a fixed draft in the combustion chamber. There are limitations on the percentage of moisture in the steam, the efficiency, the draft loss through the boiler, the stack temperature, and the furnace volume for combustion.

All of the various boiler-rating Codes which we have been discussing require that a plate be attached to the boiler showing its size, rating and other pertinent data. In the past it has been customary to show only the size number on the boiler, with the result that the stoker or burner dealer was frequently at a loss to know its capacity.

It is necessary to understand the basis on which a boiler has been rated in order to use the ratings intelligently. It is customary in the industry to regard the heating load that a boiler is required to carry as consisting essentially of the following three parts:

1. The load due to radiators, convectors, heating coils, and domestic water heaters connected to the boiler; the sum of these is known as the *Net Load.*
2. The load due to the piping connecting the radiation and other apparatus to the boiler known as the *Piping Load.* The sum of the Net Load plus the Piping Load is frequently called the *Design Load.*
3. The load that is required in addition to the above two for warming up or picking up the system when it starts from cold.

The sum of all three of these loads is known as the *Maximum Load* or *Gross Load.*

The rating assigned to a boiler may indicate the Net Load that the boiler will carry, in which case sufficient allowance has been made in determining the Net Rating to take care of normal piping and pickup allowances. This is the Rating that is represented by the terms Net I=B=R Rating and SBI Net Rating. Sometimes boilers are rated to indicate the Net Load plus the Piping Load that the boiler will carry in which case allowance is made for normal pickup. This is the Rating represented by SBI Rating which is applied to commercial steel boilers and should not be confused with the SBI Net Rating mentioned above. Sometimes boilers are rated to indicate the Gross Load that they will carry which represents the total of the Net Load plus the Piping plus the Pickup. This is the Rating that is indicated by Gross I=B=R Output and by the AGA Rating as applied to boilers designed for gas.

It may be said that the present ratings are still too complicated and confusing, but it must be realized that considerable progress has been made in the last few years toward eliminating much of the confusion, and that further progress will come in time.

SPLIT SYSTEMS

Another kind of heating installation which is worthy of mention is that known as the "split system." This system consists essentially of a hot-water or steam boiler equipped with a heat exchanger. Air is drawn through cold-air return ducts and is heated by passing through the heat exchanger, whereupon it is redistributed throughout the quarters to be heated as in a warm air furnace system. The split system has a number of the advantages of both the conventional boiler and radiator and the warm air furnace systems, such as:

(*a*) The boiler can be operated winter and summer to provide domestic hot water.
(*b*) Some of the rooms, such as, kitchen, bathroom, servant's room or garage may be heated by radiation independently of the rest of the house.
(*c*) The air can be filtered and humidified.
(*d*) The system is efficient and is automatically controlled.
(*e*) Cooling may be readily incorporated in the system.

A number of these systems were sold during the late 1930's, but their popularity disappeared rather suddenly. However, the system may become popular again when some of the objections that were encountered have been overcome. While it was fairly expensive, possibly the greatest objection to it was that its installation required the services of both a steam fitter and a sheet metal man, and there were few contractors who could supply both. Another handicap was that there were relatively few people who made a practice of designing systems involving both piping and duct work. This is not a difficult problem for heating engineers but they were usually consulted only on larger jobs. Consequently, the application of the split system was usually restricted to the larger homes.

CONCLUDING REMARKS

In conclusion, I would like to say that all of us should be aware of the possibility that within the next few years there may be a considerable quantity of substandard equipment for sale. By substandard is meant equipment that does not conform to the construction and rating standards which have been set up by the industry. It is likely that the available market for heating equipment will be large, but competition will be keen, and such a situation makes an ideal setup for the sale of cheap equipment. Unfortunately, prospective users of heating equipment are not well informed as to what good equipment consists of. This can be partly overcome by educational and public relations work on the part of the industry and partly by the exercising of caution on the part of those who specify and install heating equipment. Unfortunately, the sale of equipment of any kind which performs poorly, whether it be stokers, burners, boilers, or furnaces, hurts not only those manufacturers who made it, but also all manufacturers making that particular product. Users will condemn it and tell their friends and neighbors about it and people will turn to some other form of heating. No matter how satisfactorily the furnace and boiler industry has engineered its product, there remains an educational, promotional, and selling job to insure that only equipment which is properly constructed and rated, and will provide the comfort expected of it, finds its way into the basements of American homes.

DISCUSSION

Henry F. Hebley presiding

E. C. WEBB[1]: Mr. Hunter has given a very interesting discussion. I would like to ask Mr. Hunter if his company has noted that, in the trend toward smaller homes and the increased demand for domestic hot water because of the use of automatic clothes washers, automatic dish washers, etc., the determining factor in boiler capacity may at times be the demand of the instantaneous hot water heater rather than the house heating load on the boiler?

Is he anticipating an increase in the use of hot-water heating compared to steam heating as a result of recent publicity and interest in base-board radiators?

L. N. HUNTER: There has been a trend to hot-water heating over steam. The trend is not too rapid. Steam heating represents approximately 30 per cent of all boilers sold. We are anticipating a greater use of the heating of domestic water from a boiler, but we don't think it will increase the size of the boiler. Manufacturers have been recommending an allowance in selecting a boiler when water is heated off the boiler. During the last two or three years experimental work has been conducted by the Institute of Boiler and Radiator Manufacturers at the University of Illinois. The results of these findings have not yet been published. Recently, the Institute has decided to eliminate this allowance in selection of heating boilers. The hot-water heating load imposed by the use of instantaneous or storage is so small that it is practically negligible. That decision was arrived at as a result of considerable research work. It can not be explained in a short space of time.

H. F. HEBLEY: The gas industry and oil industry have done an excellent job of making complete units, which include the furnace or heating element and the absorption element. I am afraid the coal industry or those designing stokers and boilers haven't paid enough attention to this phase. If you have a hand-fired furnace and try to put a stoker under it, the amount of work you have to do to make a good job is considerable. I was hoping that sometime a complete stoker and heat-absorbing unit could be worked out together.

Another thing that has not been mentioned is the influence of deposition of soot and fly ash on surfaces of the boiler.

C. C. TYRRELL[2]: I think the whole thinking of our laboratory has been along the lines you are anticipating there. We are thinking in terms of a packaged unit, complete with the draft-inducing system.

E. R. KAISER[3]: The impression seems to be gaining ground here that smokeless stoves and furnaces will necessarily be considerably more expensive than conventional surface-fired equipment. The contention is based on the probable need for a magazine space in the stove and furnace and for refractory arches and combustion control mechanisms.

While it is likely that the smokeless stoves and furnaces will cost slightly more than conventional designs, we do not believe that the prices need be more than 10 or 15 per cent higher than for conventional equipment. This additional cost will be more than offset by savings in coal consumption through higher efficiency and steady operation. The customer will receive additional benefits that should make the smokeless equipment well worth buying. At this stage no one should be discouraged about the cost of smokeless equipment. We should all strive to perfect the equipment and then determine manufacturing costs from trial designs.

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1 Engineering Service Manager, Iron Fireman Manufacturing Co., Cleveland 11, Ohio.

2 Senior Mechanical Engineer, The Anthracite Industries, Inc., Laboratories, Primos, Pa.

3 Assistant Director of Research, Bituminous Coal Research, Inc., Pittsburgh 22, Pa.

J. C. MILES[4]: Domestic heating with coal now involves several separate and distinct non-cooperating independent and otherwise uninterested groups:

1. The coal producer
2. The coal merchant
3. The delivery man
4. The architect
5. The carpenter
6. The heating contractor
7. The furnace manufacturer
8. The stoker manufacturer
9. The ash hauler
10. The furnace tender

Until some one of the above factions absorbs most of the others and is able to offer a completely integrated coal-heating service, the prospective builder had better install gas. The problem of ash disposal and clean fuel seems to concern only the last two mentioned, but these two problems represent the greatest objections to the universal use of coal.

G. L. THORNE[5]: Inasmuch as there are probably many furnace and stoker agencies represented here, I apologize for the following remarks if they may appear to be critical. I was not here yesterday and also apologize if this matter has been mentioned before. In addition to the design of furnaces, boilers and stokers, I think that more attention could be given to the matter of installation and the more careful selection of proper agencies to do the job. It seems to me that the oil and gas business has been more careful than the coal business in the selection of competent agents. In the matter of furnaces, for example, in the old days a young chap would get a job with a tinner. He would have some experience in hanging rain spouts, etc., and in a short time would open up his own tin shop. Eventually, an enterprising furnace man would point out to him that he could make additional money by installing furnaces and would sell him a shipment of furnaces on consignment. He then proceeded to sell and install the same, the public assuming that he was a competent man to do so.

I think the same thing is going on today to a certain extent with reference to stokers. It seems, however, that stoker manufacturers are wont to select the plumbers more than the furnace men. In line with the resultant faulty installations, I might sight a complaint that I had about a stoker a few weeks ago. In a funeral home in which the owner had converted from an oil burner to a stoker, the installation was made with a clearance of 14 inches between the retort and the crown of the boiler. The minimum clearance should have been 30 inches. Needless to say, the stoker was completely unsatisfactory, and in a short time was replaced with gas. At the time, I talked with the man who had made the installation, and he told me he didn't know there were any specifications made by the stoker manufacturer with reference to clearance between retort and overhead parts of the boiler.

Therefore, I believe that the selection and education of competent agents is worthy of consideration.

[4] Assistant Professor of Mechanical Engineering, University of Illinois, Urbana, Ill.

[5] Butler Consolidated Coal Company, Wildwood, Pa.

Domestic Stokers

By A. O. Dady*

I AM SURE that you are all familiar with the old story of the blind men who went to see the elephant. You will remember that one who grasped his tail described him as being like a rope—a little frayed at the end; the one who endeavored to encircle the leg with his hands said, "No, he is like a tree, sound rooted in the ground"; while the one who felt his trunk curl round him exclaimed, "Nay, he is truly like a great serpent." Then the dispute waxed hot and each thanked Allah that he was not born stupid as well as blind. The fable does not tell if there was one man with sight there to show them how they were all right insofar as their knowledge of the subject went and all wrong in their description of an elephant.

Now I am to talk on the subject of domestic stokers as seen by one representative of a class of blind men—the stoker engineers. Some will say we are the most blind of all. At any rate the domestic stoker, as I see it, is not, I am sure, even the same animal that my brother engineer sees, and still less, has it any resemblance to the picture as visualized by the coal producer, the coal dealer, the stoker selling group, the manufacturers of heating equipment, or the man who lays his money on the line to buy and live with the product for better or for worse.

Perhaps our postwar stoker salesmen will be radar equipped to locate their targets and will have proximity fuses to explode irresistable closing arguments against their defenseless quarry, but unless we can get a little jet propulsion behind the material supply, deliveries are going to be slower than the coming of peace to this old terra firma—if in these atomic days the world still can be considered terra firma, and not, what mathematicians call, transient phenomena.

I will not attempt to describe the postwar stokers that will begin to appear next year. My colleagues, among the engineers, have not described their brain children to me and I maintain a modest reticence as to my own. It is a pretty sure thing that these postwar babies will have a strong family resemblance to their older brothers; but it is equally certain that the time from 1942 to 1945 has not been wasted and that the production techniques learned during the war will have been combined with the operational experience gained before and during that period to build better stokers than those we heretofore have had. Those who do not learn will not survive.

We live in a capitalistic society. We are motivated by this condition. The stoker manufacturer must make a product that will appeal to the consumer in sufficient degree that he will spend his money for such a product in preference to a new radio or washing machine or oil burner, or even for a competing stoker. This is the price of survival and the source of the money for paying the workmen who build, the engineers who design, and the multitude of suppliers who make the parts and the raw materials. Maybe even enough money will be left to pay a little dividend—after taxes—to those who furnish the money to back the enterprise.

There must be a nice balance between what we put into and what we leave out of the stoker. First, I would say that the stoker must be well and honestly built to give the customer trouble-free performance and a reasonable life expectancy. If it is to be salable over a wide territory, it must capably handle many coals of widely varying characteristics, or it cannot be built and sold in volume, it will be high in unit cost, and it will appeal only to a limited market. The stoker must be pleasing in appearance or it will suffer in comparison to others on the salesroom floor—for that is where

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* Chief Engineer, Stoker Division, David Bradley Manufacturing Works, Bradley, Illinois.

sales are made. Dimensionally it must be adaptable to a wide variety of boilers and furnaces, otherwise it cannot be installed in many homes. The stoker men know that the conversion market still is their bread and butter.

Economics still dominates the stoker market as it does all others. Coal still carries with it the stigma inherited from the days when it was poorly prepared, dirty as delivered and dirty to handle. As a result, those people who can afford higher heating costs often choose oil or gas, because they haven't been made aware of the change. The preparation of coal today by the better operators has produced in stoker coal a fuel that is clean to handle and which customers prefer even at increased costs per ton. The coal producing industry, however, also consists of many small operations without facilities for such preparation and to them the domestic stoker is a closed field. Some say that the increasing number of stokers soon will require the crushing of larger sizes on an increased scale. "Why not build a stoker that will take anything up to two or three inch sizes?" they ask. "Well, why not?" If these people have the courage of their convictions and the money to back them, the field is open. I venture to say that if the trend to the Diesel locomotive and the gas turbine continues, many coal producers will look avidly toward the market for coal prepared to satisfy the domestic stoker market at a price that will sell it.

Economics again is dictating the building of smaller, more compact homes. The comfort value of insulation, winter and summer, is more widely appreciated. Heat losses and, likewise, heating plant capacities in postwar homes will be lower than those for homes built before the war. If ever the building industry can shake itself free of its Pre-Renaissance Craftman's Guild complex and realize that lower cost homes can and should be built in factories and erected only on the site, and if only some of the antediluvian building codes that throttle any new material or any new method can be obliterated, there will be work the year-round for more men than ever worked in the building trades, and at the same time there will be good homes at a reasonable price for millions of Americans who now live in buildings not much more comfortable than the sod hut or log cabin of our pioneers. Such pre-fabricated homes can have heat losses small enough to make present day standards look ridiculous.

Speaking seriously, however, these small, low heat loss homes carry with them these implications: first, the reduced size of the heat exchanger unit will require stokers of correspondingly smaller capacity and physical size; second, burning rates per square foot are likely to increase rather than decrease, for the burners must be reduced in area to fit into the smaller firebox and still leave room enough around the outside for either clinker storage or ash removal; and third, smaller burners in turn require that the diameter of the feed screw and tube be reduced, with the result that the top size of the coal that can be handled without crushing is lowered.

The alternative is an entirely different method of feeding and burning the fuel, and also, of removing the ash. If there is such an alternative, it has not yet appeared either in the patent literature or on the market. When and if it does appear, it must undergo a considerable period of development and refinement and it must clearly demonstrate its ability to outperform the screw-type under-feed stoker in reliability, in adaptability to coals of widely varying burning characteristics and sizes, and in lower manufacturing costs. The correct answer to this problem certainly is worth a lot of money.

Turning from what eventually may happen to what probably will represent immediate postwar practice, I think we shall find that the clinker-type stoker is still the dominant class, particularly in the smaller sizes. In the sizes adapted to large homes we may expect to see in production ash removing, binfeed models capable of handling a limited variety of coals not well adapted to the clinker type. Much experimental work has been done on these, but they still have to be simplified and refined to lower their first cost and higher service expense if they are to offer serious competition to the class of buyer who is in a position to afford them instead of oil or gas. The binfeed stoker in the clinker type is gradually gaining ground and would do so faster if architects and builders would give any consideration to the location of the heating plant and bin with relation to one another and in relation to installation requirements. It still isn't easy to pipe coal around three or four corners.

Salesmen, generally speaking, have failed to take full advantage of the opportunities offered them when interested prospects permit them to survey their homes. For example, a year-round, low cost, domestic hot water supply, using the stoker, is one of the better sources of additional profits most frequently neglected. Besides, there are many others, from new smoke pipe or chimney cleanout doors, to major heating plant repairs and improvements, which an intelligent survey will uncover and aggressive salesmanship can convert to plus profits.

In regard to the technical details of burners, air controls, fans, transmissions and controls, I am sure that every competent stoker manufacturer has used, to good advantage, the time when production of stokers was at a standstill because of wartime restrictions to study and apply the lessons that had been learned and to embody them in his postwar product. How well this has been done we shall see next year.

You all will not agree with my conclusions. I am in much the same position as the grandmother coming for a visit who met her young grandson on the street as she approached the house. She stopped and said, "Hello, Johnny."

Johnny said, "Hello. Who are you?"

"I'm your grandmother coming to visit you," she replied.

"You are my grandma. Which side are you on?"

"I'm on your father's side, Johnny."

"Huh! Just wait until you get inside and you'll find out you are on the wrong side!"

DISCUSSION

Henry F. Hebley presiding

C. H. SAWYER[1]: It is always a pleasure to talk stokers with Mr. Dady; and I am sure that everyone here from the coal industry is gratified to see the equipment manufacturers so well represented, both in the audience and on the program.

Through these recent, difficult years we have naturally continued to stress the development of better stoker coals and better ways to burn our own stoker coals in our Kearny laboratory, but we have also, of course, followed new design work with interest.

Mr. Dady mentioned the lack of radical changes in stoker design. This is certainly an accurate description of the general picture, but we have seen two or three rather radical designs. I should like to mention one, really a very interesting size reduction of the familiar dump-grate stoker, with some patented features which adapt it to domestic use. This stoker, developed by Mr. D. J. Mosshart of the Westinghouse Stoker Division, has seemed to us the most promising innovation for application to strongly coking eastern coals. Our report on this stoker is freely available to interested persons in the industry. It is not, as yet, a commercially developed machine, but Westinghouse has waived rights in its exploitation, and we understand that Mr. Mosshart is going ahead with his own efforts to commercialize it.

E. C. PAYNE[2]: These stoker developments are intensely interesting. We must build stokers soon that will handle the low-fusion coals with the same facility that some stokers now handle the high-fusion coals. Domestic consumers in almost all income brackets now demand fully automatic heating, cleanliness, and convenience in their heating plant and disregard the cost to a great extent if the service is reliable and no extra labor is involved. Even those with

1 Research Division, Koppers Company, Inc., Kearny, N. J.

2 Consulting Engineer, Consolidation Coal Co., Inc., 30 Rockefeller Plaza, New York, N. Y.

limited funds are not happy about removing clinkers by hand or ashes from the fuel bed, or periodically handling dusty coal. The coal industry is doing a good job of furnishing dustless, treated, prepared coals, but as long as the dealer is responsible for the actual delivery, his service must be neat and clean both inside and outside the residence.

The Butler Consolidated Coal Company's representatives raised the point of the proper selection of Field Agents and Representatives for boilers and stokers. I would like to emphasize the importance of appointing competent and well-trained agents for sales, installation, and service of both coal and combustion equipment. The finest type of coal and the best designed combustion equipment will not give consumer satisfaction if the equipment is improperly installed and the coal is improperly used. The whole job is a headache from start to finish for both the consumer and the supplier. It is important, therefore, that stoker manufacturers and coal producers follow through with proper installation and proper service to achieve utilization satisfaction. This conference is certainly an excellent opportunity for an exchange of ideas that will improve the service which equipment manufacturers, coal producers and their agents, can provide for the ultimate consumer.

J. B. HILDERBRAND[3]: On this question of fuel, I know very little about bituminous coal, but I am familiar with coke and anthracite. In the early, dark days of the coke stoker, which Mr. Shaffer described, we had many trying and interesting experiences.

We knew that the fuel processing for stoker firing was very poor and we argued until blue in the face but got no results. One of the executives had a stoker in his home and could see no reason for special sizing, but his deliveries always received special attention. Once, when he needed fuel I saw to it that he received a load of the regular run of coke. Needless to say, everyone received improved sizing after that delivery.

The coal operators do a grand job of preparing the coal. The stoker manufacturers do a good job of producing their equipment.

I believe that when a stoker is installed the customer should be advised of reputable coal dealers in the area in order to get the best results from his equipment. Good stoker equipment should not be blamed for poor coal or incorrect size of coal.

N. M. GEBHARDT[4]: There is something I would like to add. We have talked about the matter of the installer. I think one reason why the oil-burner distributor and gas-burner distributor has done so well is because the producer makes it his business to see that the consumer gets service through that outlet.

With the coal stoker the consumer has to have service if the stoker is to operate efficiently. One point at which service can best be rendered is by the retail distributor who supplies the coal. It costs money to provide this heating satisfaction, but it is more than made up in the reduction in the fuel bill of the consumer.

The producers as a whole have given little or no consideration to distributing their product through the type of outlets that can give the consumer satisfaction. They will go into a community, place their product with five or six retail distributors, and then it is a case of trying to meet the lowest price of any one of the competitors who distributes the same coal. These competitors assume no responsibility beyond dumping the coal into the bin. Consequently, the retail distributor who tries to render the service necessary for consumer satisfaction finds that it is impossible to render the service because of the competition to which he is subjected from the other dealer outlets on the same coal in the same community.

K. C. RICHMOND[5]: It seems to me that we are unduly pessimistic. Maybe I should not say anything because I have had only 16 years experience with five stokers in my basement. I have been getting good stoker coal and good service. I have an ash-handling stoker, but how many of us here use ash-handling stokers? Since there appears to be only three of us, I can talk safely. It has cost me over $5 per ton for coal for service and maintenance to oper-

[3] Stoker Engineer, The Bryant Heater Co., Cleveland 10, Ohio.

[4] 1426 Chestnut Street, Erie, Pa.

[5] Editor, *Coal-Heat Magazine,* Chicago, Ill.

ate a bin-fed, ash-handling stoker. That is too much; the public won't stand for it.

J. E. TOBEY[6]: Why?

K. C. RICHMOND: Because you can't get the ultimate in equipment overnight. It takes time, research. You can't go from the Franklin Stove to the complete heat machine in a year or two. It takes time. It has cost me over $650 for equipment and maintenance the past eight years. It is excessive. I am 100 per cent for Mr. Dady and his common-sense approach.

DISCUSSER FROM FLOOR: Is your reference to anthracite or bituminous?

K. C. RICHMOND: Bituminous.

DISCUSSER FROM FLOOR: I have had 16 years experience in my home. The ash-removing cost was less than $10.

[6] Director, Fairmount Coal Bureau, New York, N. Y.

Service Water Heaters

By Cecil C. Tyrrell*

ACCORDING TO the Bureau of Census, there were 1,257,000 water heaters of all types manufactured in the United States in 1939. Of this number 357,000 were of the side-arm gas-type, used for supplying intermittently heated hot water. Besides this number, a great many of the hot-water and steam heating systems installed were equipped to supply continuously heated water, at least during the heating season. K. C. Richmond in *Coal-Heat,* July 1945, stated that a great many of the stoker- and oil-fired units installed recently include year-round, indirect service-water heating as a sales feature. However, in spite of this very considerable production in the last normal year before the war, the Office of Civilian Requirements of the WPB in June 1944, estimated that only 14,000,000 individual homes of the country's 29,000,000 dwelling structures were served with hot running water. Mr. Richmond further stated that the kitchen range, according to the best estimates that can be made, probably furnishes the hot water in 15,000,000 of the homes of the country. It can be seen from these figures, and because most home purchasers put a generous supply of hot water as one of the high items on their list of requirements, that the provision of a means for supplying a satisfactory amount of water of proper temperature should be a paramount consideration of the consumer, the architect, the plumber, and the manufacturer, as well as the supplier of the fuel.

In discussing the various types of hot water heaters built for the use of solid fuels, the following classifications will be used: (1) water backs for kitchen ranges and warm air furnaces, (2) hot water supply boilers, and (3) indirect heaters.

* Senior Mechanical Engineer, The Anthracite Industries, Inc., Laboratories, Primos, Delaware County, Pennsylvania.

WATER BACKS FOR KITCHEN RANGES AND WARM AIR FURNACES

In Figure 1 are shown several types of water backs that are used in a great many installations for the heating of service water, particularly during the season of the year when the unit in which it is installed supplies the house heat. Practically all of the houses in which there is running water, but no central system, and that use solid fuel in the kitchen range, will have this type of water heating the year-round. Many of the warm air and gravity hot-water central heating installations use this means of heating water during the heating season.

Harding and Willard in *Heating, Ventilating and Air Conditioning*[2] give a value of 14.5 gallons of 100-degree-rise water per square foot of heating surface as a safe figure to use in calculating the capacity of such a back. The net house heating capacity of the heater will be decreased by an amount of 12,000 Btu per hour for each square foot of back installed.

The advantages of the water back are: (1) simplicity, (2) low cost, and (3) the making of hot water available from units not otherwise capable of supplying it. The disadvantages are: (1) difficulty of control, because the output depends upon the burning rate of the heater in which it is installed; (2) the tendency to be of improper size to meet requirements; and (3) the failure to supply year-round hot water when installed in central heating systems.

HOT WATER SUPPLY BOILERS

The hot water supply boiler, commonly known as the bucket-a-day, jack stove, etc., fills the need for a separately fired service-water heater for installation

2 Published by John Wiley & Sons, Inc., New York, N. Y. (1932).

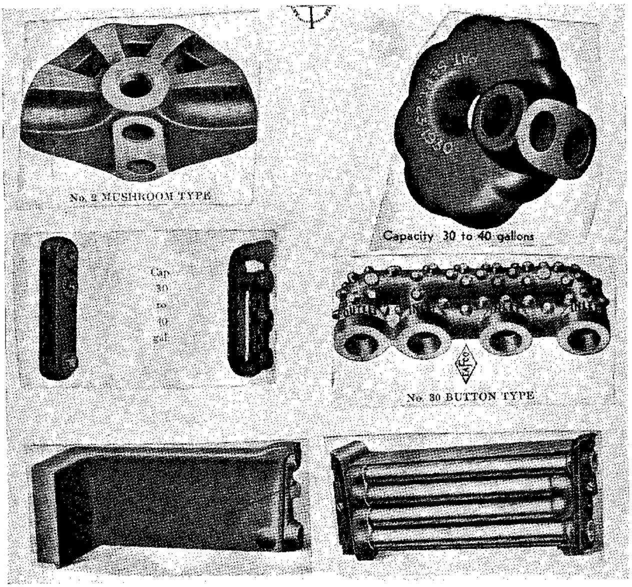


FIGURE 1. WATER BACKS FOR KITCHEN RANGES AND WARM AIR FURNACES

water per hour. This unit operates on either rice or buckwheat Anthracite, and makes a very satisfactory installation where automatic hot water is wanted at minimum fuel cost.

Probably no type of hot water heater has come in for more criticism than the hot water supply boiler. This has been mainly due to the improper sizing of the unit and the failure to provide any type of automatic control. However, with proper selection of boiler and controls, a convenient, satisfactory, and economical supply of hot water can be had from these boilers. Various types of controls and control installations for these boilers are shown in Figures 5 and 6.

where the central heat is supplied by a warm air furnace or by gravity hot-water systems. The capacity of these units varies from 30 gallons of 100-degree-rise water per hour for the small home to several thousand gallons per hour for the apartment or commercial establishment. Figure 2 shows several types of these heaters; their principal advantages are simplicity, low cost, and economy of operation.

In Figure 3 are shown magazine-feed types of hot water supply boilers which greatly increase the length of the attention interval. Figure 4 illustrates a stoker-fired hot water supply boiler of recent design. This unit is designed so that it may be hooked to any storage tank holding from 30 to 200 gallons and has a capacity of from 15 to 60 gallons of 100-degree-rise

INDIRECT HEATERS

The tendency toward the installation of completely automatic heating units in the areas where hot-water and steam central heating systems are popular has made the use of the indirect hot-water heater for supplying year-round hot water increasingly important. These heaters have been popular for a long time for supplying service water in steam-heated houses during the heating season. In order to lower the total installation cost, the use of such heaters in steam boilers, both oil- and stoker-fired, and in hot-water heating systems using circulators, has become increasingly popular. The term "summer-winter hook-up" is being heard with increasing frequency in the Philadelphia area where hot-water heat is widely used. With the accelerated use of the "Constant-70" type of control and radiant heating, the use of the indirect heater for year-round service water

FIGURE 2. HOT WATER SUPPLY BOILERS

should continue its pre-war trend of increasing popularity in the postwar years.

In Figures 7, 8, and 9 are shown different types of indirect heaters. The type to be selected depends, of course, upon the particular installation. Factors such as space, type of boiler, type of controls used, and the amount of water to be supplied govern the selection of the heater for each installation. The use of the tankless heater seems to be gaining in favor largely because it does away with the necessity of an external storage tank.

Controls necessary to meet different requirements when these heaters are used in various installations are shown in Figure 10. With steam or with hot-water boilers where the water is maintained at too high a temperature, it may be desirable to use a "thermo-check" in an externally mounted heater to minimize storage tank corrosion and to prevent the water from becoming too hot for safe use. In these systems when an instantaneous heater or built-in heater is used, it is desirable to use a tempering valve to avoid the danger of being burned by the water being drawn from the heater or tank.

The use of indirect heaters in typical steam boiler installations is shown in Figure 11, whereas Figure 12 shows the use of indirect heaters in typical hot-water boiler installations. Also shown is one of the outdoor bulb "Constant-70" type controls in a hot-water system. This gives a very fine type of heat with practically no

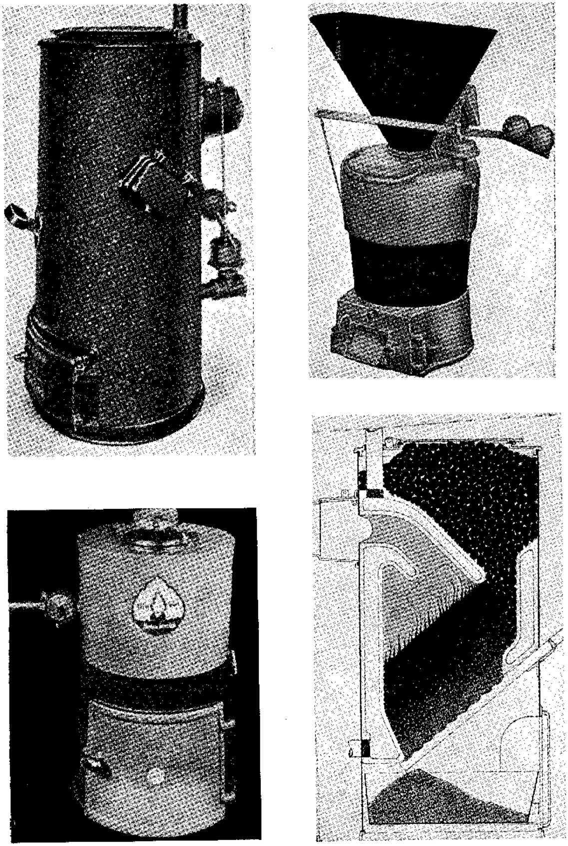


FIGURE 3. MAGAZINE FEED HOT WATER SUPPLY BOILERS

temperature variations. The fact that year-round service water is obtainable with such a control helps defray the added expense of the control since an additional hot water heater for the summer months is not necessary. Moreover, in climates where the humidity in the summer makes the drying effects of the heat given off by the furnace desirable, furnace operation during the summer may be an asset rather than a liability. This was demonstrated along our Eastern Coast this last summer when houses without any heat were bothered considerably by mildew and by falling wallpaper.

A tankless coil built into an Anthratube is shown in Figure 13. This is a new type of domestic heating unit developed by the Anthracite Industries Laboratories; it combines the automatic stoking mechanism with the boiler in a single package. This unit has a high degree of flexibility and makes an excellent heater for supplying year-round hot water with either a tankless or tank-heater type of indirect coil.

HOT WATER REQUIREMENTS

While it is quite easy to determine the hot water requirements of the average family, it seems to be a very common complaint that a great many installations are inadequate to supply the minimum requirements of a household, at least at certain times of the day or week. A test program for the evaluation of the performance of water heaters that approximates average operating conditions would do a great deal to remedy this situation. Such a procedure was recommended by Drs. H. J. Rose and R. C. Johnson in a paper presented before the American Society of Heating and Ventilating Engineers in July 1939.

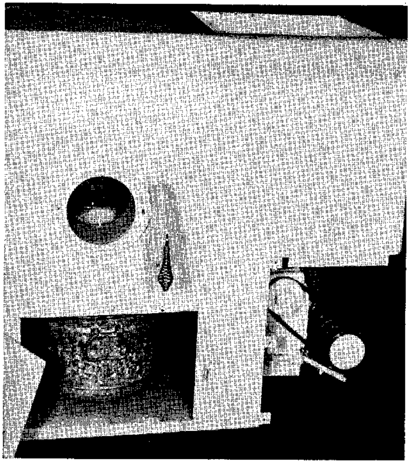


FIGURE 4. STOKER FIRED HOT WATER SUPPLY BOILER

From the standpoint of consumer satisfaction, it is very important to evaluate more than maximum output at steady flow. It would be desirable to determine such things as minimum output, rate of pickup after banking, length of banking period without attention, and attention interval at rated output for hot water supply boilers. A draw-off program that would approximate the type of demand encountered in household use should be determined for all types of heaters. Since all of the heaters equipped with storage tanks, and even the tankless heater to a lesser degree, possess considerable inertia, it is important that the storage capacity be taken into consideration in determining the daily draw-off capacity of the heater. The maximum-output rating may not be at all adequate in determining the adequacy of the heater for the supplying of service water to a family with a 50-gallon per day demand, one third of which occurs in the 15 minutes between 8:00 and 8:15 A.M. The size of the storage tank may be much more important than the maximum output rate of the heater. In Table I, a draw-off schedule recommended by Rose and Johnson is shown for a 50-gallon per day demand for a practical laboratory test during a working day. For a heater of larger capacity the amount drawn would, of course, be increased in proportion.

TABLE 1. Laboratory Draw-off Schedule

Hour of Draw-off	*Gallons of Draw-off* (100° rise)	*Btu in Draw-off* (100° rise)
8:00	15	12255
9:00	6	4902
10:00	3	2451
11:00	1	817
12:00	3	2451
1:00	9	7353
2:00	3	2451
3:00	2	1634
5:00	8	6536
	50	40850

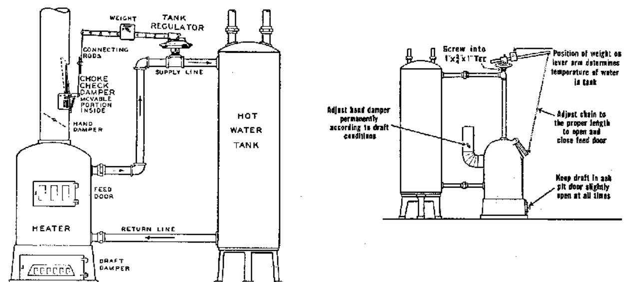


FIGURE 5. CONTROLS FOR HOT WATER SUPPLY BOILERS

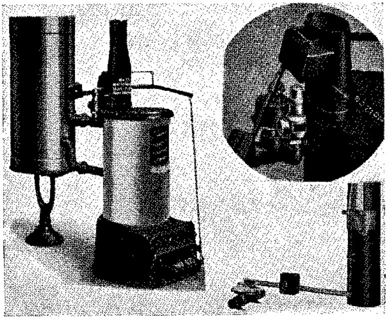


FIGURE 6. CONTROLS FOR HOT WATER SUPPLY BOILERS

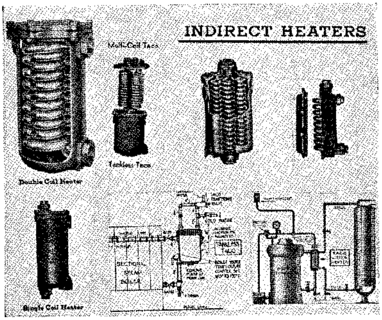


FIGURE 7

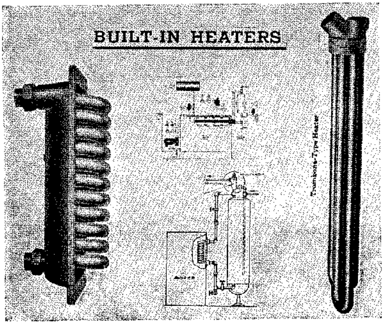


FIGURE 8

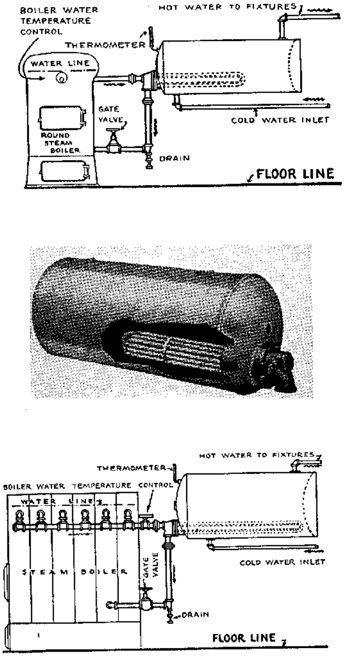


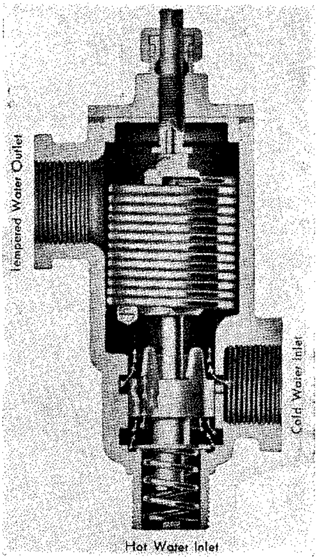
FIGURE 9. TANK HEATERS

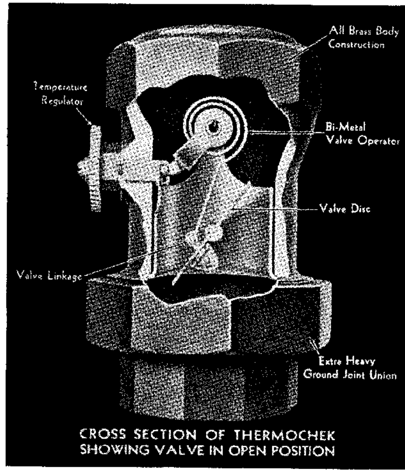
In conclusion, it may be well to briefly summarize the foregoing discussion as follows:

1. There are a number of satisfactory, well-designed, solid-fuel-fired hot water supply boilers on the market.

2. These units may have their attention interval considerably lengthened with the addition of magazine or stoker feeding.

3. It is as unreasonable to expect satisfactory operation without automatic controls with solid fuel as with any other type of fuel.





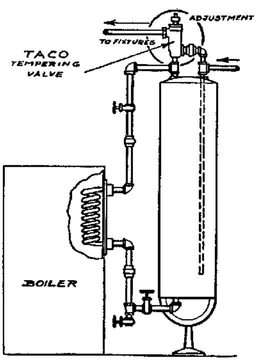


FIGURE 10.
CONTROLS
FOR
INDIRECT
WATER
HEATERS

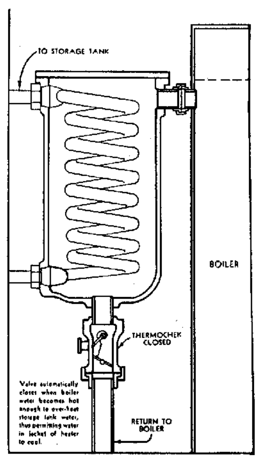
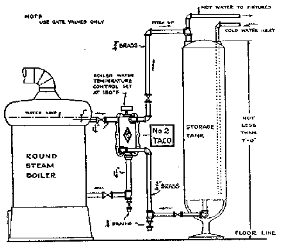
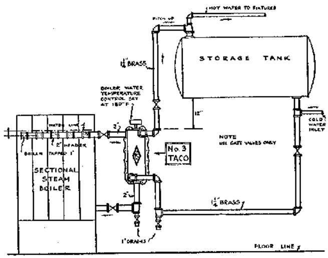


FIGURE 11.
INDIRECT
HEATERS
IN STEAM
BOILERS

STEAM

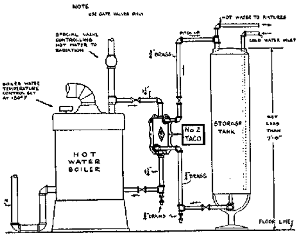


ROUND STEAM BOILER AND VERTICAL STORAGE TANK FOR AVERAGE RESIDENCE HAVING 1 TO 2 BATHS.

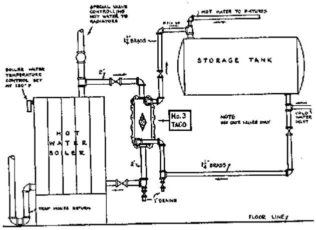


SECTIONAL STEAM BOILER AND HORIZONTAL STORAGE TANK FOR AVERAGE RESIDENCE HAVING 2 TO 3 BATHS.

HOT WATER



ROUND HOT WATER BOILER AND VERTICAL STORAGE TANK FOR AVERAGE RESIDENCE HAVING 1 TO 2 BATHS



SECTIONAL HOT WATER BOILER HORIZONTAL STORAGE TANK FOR AVERAGE RESIDENCE HAVING 2 TO 3 BATHS.

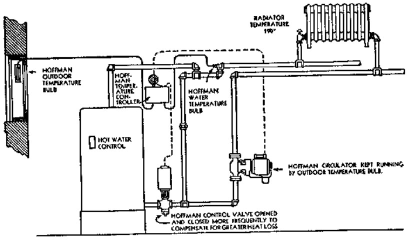
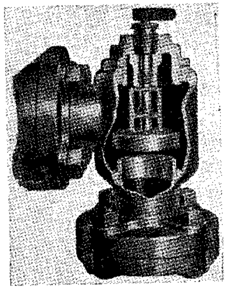
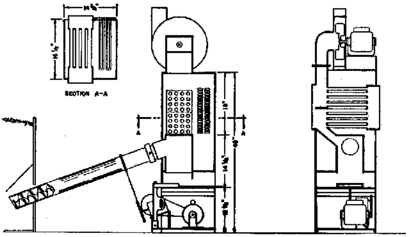


FIGURE 12.
INDIRECT
HEATERS
IN HOT
WATER
BOILERS



4. Service-water heaters may be built integral with automatic, solid-fuel-fired units as easily as with those using other types of fuel, and have the same advantages.

FIGURE 13



5. For maximum consumer satisfaction there should be a standard method of rating service water heaters that will, as nearly as possible, measure a heater's ability to do the job for which it has been selected. This should, of course, be of equal interest to the producer, as consumer satisfaction is the best salesman of such equipment.

Finally, with these things in mind, the hot water supply heater can be selected on the same basis as the building heating equipment, and it is not limited by the lack of satisfactory types of heaters and controls from which to select.

DISCUSSION

Henry F. Hebley presiding

P. L. GROSS[1]: I would like to question Mr. Tyrrell on one slide, the one showing production of a stoker manufacturer's hot-water unit. What is the price range in that unit? Is it reasonable for the average buyer?

C. C. TYRRELL: I am not sure I can answer that. I do not have price figures on it.

P. L. GROSS: Is that currently in production?

C. C. TYRRELL: Yes, a hundred units last year I believe.

P. L. GROSS: On one-half pound per hour what is amount of hot water delivered?

C. C. TYRRELL: One-half pound is roughly 6500 Btu; at the efficiency of 60 per cent, this would be about 4000 Btu per hour or 400 pounds of 100-degree-rise water.

P. L. GROSS: Does your theory hold practical in this unit?

C. C. TYRRELL: I don't see why it wouldn't.

T. S. SPICER[2]: I don't remember hearing or seeing a more complete coverage of service water heaters than we had here this morning. The service water question is a "hot" one because service water in the past has been too cold. An adequate supply of hot water is high on the list of the things that people desire for the home as shown by many of the recent surveys. Many homes are well-heated by automatic and semi-automatic central heating systems, but at the same time service water is heated by antiquated methods. I can't think of anything more discouraging than to come in from a game of golf all set for a shower, go into the bathroom whistling, and come out of it cussing.

A few years ago the Comfort Heating Laboratory

[1] Coal-O-Matic Stoker Co., Trucksville, Pa.

[2] Assistant Professor of Fuel Technology, The Pennsylvania State College.

of The Pennsylvania State College studied the problem of using bituminous coal for heating service water. As a result of that work, Mineral Industries Bulletin No. 37, entitled "Heating Service Water with Bituminous Coal" was published, which I believe some of you have read. In this publication, we point out the importance of proper installation of service water heaters. For example, in practically all types of water heaters, the operating principle is the gravity flow of water from the tank through the heating medium as a result of the change of temperature. Just as hot air becomes lighter and rises when it is heated, so does water. Unless this natural circulation can be maintained, a water heater cannot function properly. Thus, small air pockets caused by low spots in the piping must be eliminated.

Another detail that adds to the satisfactory operation of service water heaters is the installation of the horizontal tank rather than the old-fashioned vertical installation. Better circulation of the water and a more uniform temperature of the water in the tank are possible with a horizontal installation.

I personally have been a strong advocate of the indirect type of water heater, especially when used in conjunction with stokers or automatic types of heating systems. With this arrangement it is possible to have year-round, automatic hot water with either steam or forced hot-water systems. There are so many angles to talk about on this service water problem that I am sure we don't have time to touch very many of them this morning.

Controls and Heat Regulators

By R. H. Warmee*

IT IS A far cry from a modern movie house with clean, pure, refreshing air containing just the right amount of moisture, warmth or coolness to the climate of 300 million years ago when the sun was father of the heat family and coal was his first offspring, when trees were so large they would shade the Empire State Building and fern-like jungles were luxuriant, beyond our conception. Air and climatic conditions were such as to promote a very rapid growth of these immense plants. It is likely that they grew so fast that they never became woody and were soft and pithy, with much more foliage than our present trees. There was so much carbon dioxide in the warm, moist air in which these pre-historic forests grew that present-day life would not have been able to live in it. Perhaps this was nature's way of purifying the air in preparation for the coming of the higher animal life. It is strange that the most intelligent of these animals should have been trying so hard for the past few centuries to refoul the air made clean in the process of evolution, air, which in its purifying, made modern fuels possible.

"Home, Sweet Home—be it ever" . . . is the song that men have sung in their hearts, if not in words, since the days when the cave man stood majestically at the entrance of his cave with a shillelagh in one hand and with his spouse by the fore-lock in the other. Homes, the dreams of men, be they castles or cabins, began with the building of an outdoor fire, around which the primitive hunter and his family gathered. Later there were crude dwellings with top openings to carry off smoke and fumes from a fire moved inside, the cradle of indoor heating. Next came structures of stone and wood with fireplaces and chimneys. At one time during this evolutionary process, primitive man built double walls of stone and set his fires in between to heat the stones; this was the beginning of panel heating, which is being contemplated today. Eventually, there came the stove, first, of stone, then of iron and now, the modern furnace or boiler automatically fired with modern fuels—solid, liquid, or gaseous.

The onward march of man has been marked by diligent search for all means whereby his work shall yield him greater dividends in health, comfort, and convenience, and more leisure to enjoy the fruits of his toil. In his age-long struggle for existence, man has sought constantly to enhance the surroundings of his domestic life. To this end modern controls play an increasingly important role. Outside storms may howl and winds may blow, yet indoors, heating controls will respond patiently and accurately with an endurance that puts man to shame. Or, as the cycle changes with the procession of the equinoxes, and man seeks respite from a sweltering sun and a humid atmosphere, proper controls will again produce a livable environment.

From a material point of view the development of mankind has been marked by his increasing ability to exercise control over the forces of nature and over energy obtained from natural sources. This element of control is the essence of engineering progress. The last of the natural conditions to be almost completely subjugated is the atmosphere from which we derive oxygen for breathing and which serves as a medium for the dissipation of body heat. It is known that we are most comfortable in an atmosphere which embodys a temperature within a given range, a definite amount of air movement, a range of wall temperatures, and a definite degree of humidity. These four elements are so inter-related that when in perfect balance they create a human comfort zone.

* Sales Promotion Manager, Minneapolis-Honeywell Regulator Co., Minneapolis 8, Minn.

It is obvious that outdoor air is not necessarily ideal from the standpoint of health or comfort. It may be too cold or too hot, too dry, or too still. With this knowledge, engineers and manufacturers have endeavored to design and make available equipment that would provide "manufactured weather." It has simply been a case of gaining control over the conditions of nature. If the air is too cold, it is heated; if too warm, it is cooled; too dry, moisture is added; all under control.

Not so many years ago, a fireplace was considered an excellent means for heating a home. George Washington, Thomas Jefferson, Abraham Lincoln, and many other great and near-great men lived and studied before a fireplace. But man was not satisfied and the stove or base burner came along. Following this, we put a furnace or boiler in the basement, fired it by hand with shovel and poker and kindling wood—it was called a central heating plant. But, whenever we forgot it, it got too hot or too cold or went berserk and we started all over again. Again man was dissatisfied and along came controls to make automatic heat possible. We found little gadgets to be more accurate, more dependable, more convenient and more economical than we could be and we liked them. But—are we satisfied? No, we want something even better, and, mind you, we are going to get it, come hell or high water.

In the past, the architect was more of an artist than an engineer. He was more concerned with the appearance of a window than he was the comfort or lack of comfort which the window would produce. Some of the builders and real estate salesmen have sold pretty fixtures, fancy bathrooms, glamour kitchens, ornate fireplaces and a ding-dong bell that sounded like the chimes of Westminster. They decorated the new house with furniture, new drapes and rugs, and showed all the new gadgets. They fell in love with the kitchen, the shower, the recreation room, and very casually, if at all, little mention was made of the heating system. In fact most of the mamas said, "That's your department, Dad." Dad passed it off lightly, saying, "I guess it's all right; don't know too much about it anyhow." And we let it go at that. There are some houses that have been built in the last two decades in which you couldn't get a coal bin in the basement if you wanted to. Now all this, I think you'll agree, "ain't right, McGee," as Molly would say, because this thing called a heating system is one of the most important things in the house. The fuel bill is an important item in the family budget and the kiddies' health and your bodily comfort are mighty important also.

My purpose is not to give you a wealth of scientific and technical data; it is only to acquaint you with some facts and give you some hints for the future. There is no question but what postwar builders are anticipating marvelous automatic devices to accomplish almost everything from opening the garage doors to cooking the morning egg, all with buttons. Tomorrow's house builder wants and expects to move interior walls by pushing a button, thus changing the entire atmosphere of the living room. He expects to push another button or perhaps twist a dial and by indirect lighting, change the color scheme of the home. He expects television, correct illumination, air conditioning, and above all, he expects *livability*. To this end, men in the heating and allied industries are burning the midnight oil in planning to meet this requirement, and for the first time in history, home owners, tenants, and dwellers in apartment houses are going to be eager to learn what the heating industry has to offer. No longer regarded as a necessary evil, the heating system of the future will rule supreme. Just as "Flo" Ziegfield glorified the American girl, the heating system is going to glorify the American home of the future. The heating system will provide comfortable and healthful warmth in all sections of the house and will consume fuel more economically than present models, and Mr. Consumer will demand these improvements.

In the future, many of our homes are going to be zoned or sectionalized; both words have the same meaning. This development is not new for almost every large office or public building that was built during the past decade has been heated or cooled by zones, and just before the war started, a few private dwellings were zoned. Zoned heating has proved itself in schools and other buildings and is a "must" for the future in residential construction, at a cost well within reach of every builder who desires something more than just four walls and a roof. Under this system, each dwelling would be divided into at least two and probably three or more zones. The sleeping portion of the postwar home will be one zone, the living portion another, and the service a third. If it is to be a large house, zones may number five or six. Temperatures in each zone will be automatically maintained at pre-determined levels. It will not be necessary to roast in the living room in order to raise the temperature in the bedroom just before retiring. It will not be necessary to open windows and doors in the kitchen in order to keep the temperature of that room down to a reasonable level. In effect, each zone will appear to be heated by its own separate and distinct heating system. For instance, the temperature of the bedroom will be less during the daytime and come back to 70 before the family retires at night. The living and dining room temperatures will be comfortable during waking hours and less at night, while the kitchen and laundry, where physical activity makes higher temperatures uncomfortable, will be maintained at the desired temperature. The advantages of such a system are obvious; and will be economical. The fuel now going to heat an unoccupied bedroom will be available for the living room and vice versa. Although some modification in the conventional layout of the present heating system will be necessary in order to accomplish zoning, this change is relatively minor.

In the future, our apartments are going to be made comfortable by personalized or individual control of each room, suite, or section, with standard electric or pneumatic controls or combinations of both. Any of these systems may consist of modulating or two-position thermostats or valves, as best suits the particular heating system. New apartment buildings can be planned so that the individual apartment is served by a separate branch from the heating plant. The thermostat in the living room controls a motorized valve in the separate supply line to all radiators of the apartment. Sectional control of individual apartments provides a means of incorporating rooms of like usage and temperature requirements under control of an individual thermostat and control valve. A thermostat in each section simultaneously controls individual radiator valves installed on each of the radiators in the section. In individual room control each room is provided with a thermostat which controls only the radiator or radiators in the respective rooms. Individual room control can be easily applied to existing apartment building.

The key to this magic will be the thermostat, not one but several, and not the conventional thermostat in use today, although it will serve the purpose admirably, but an improved electrical device, more sensitive, accurate, and safe than any instrument previously made. And speaking of thermostats, it doesn't take scientists or engineers to make us realize that we have been asking a whole lot when we expected one little thermostat stuck on the wall of one room to regulate the temperature of the entire house. You can readily imagine how antiquated this form of control will be in the new day. Today it is possible to maintain room temperatures within four-tenths of a degree for months on end with the new devices. Along with all this, the new thermostat in appearance will be as modern as the house itself. It will be small and designed to blend with the surroundings, and it will add prestige and appearance to any postwar home.

I mentioned a few moments ago that man is never satisfied. In the future he is not going to tolerate poor circulation of the heating medium, cold floors, hot ceilings, and cold walls. The fault has been the intermittent flow of heat which means the heat is either on full blast or completely off; the radiators, either hot or cold; and the fan, if there is one in a warm air system, either on or off. These faults will be corrected through a constant flow of heat at the exact temperatures required. Under present conditions, in most homes, when the thermostat calls for heat, the furnace or boiler roars to full capacity until the desired temperature is reached and then shuts off and the temperature then starts its steady decline. This operation goes on in the mild weather of spring and fall, as well as in the winter. To correct these points of dissatisfaction, the heating medium will be modulated, which comes from the Latin word "modulatus," to measure. In other words, the source of heat will be measured to give the amount of heat continuously which has been pre-determined by the occupants.

Into the automatic heating world has come a new concept in home heating—we call it "Moduflow." Reduced to the parts from which it was coined it stands for "Modulated flow." Therefore, MODUFLOW means modulated heat with continuous flow of the heat medium (air, water, steam). What we call "Moduflow" is really the name for an improved heating system. It is not a proprietary product to be licensed to a few. It presents an opportunity for everyone in the heating industry to offer what the public in the postwar years will want, incorporating his own individual sales approach, but directed to a clearly understood common goal.

Obviously, Moduflow is the direct opposite of the "on-off" or intermittent heat supply that prevails today, which, we predict, will be obsolete in the better systems of tomorrow. The Moduflow System of control developed by Minneapolis-Honeywell is not a new development, nor is it in any sense an untried experiment. The method of application of heat modulation, or continuous flow, has been applied over a period of years to the heating of large structures, such as public and commercial buildings, industrial plants, and apartments. The Minneapolis-Honeywell engineers responsible for this development have now adapted it to the house, so that it will be available in the postwar period to every home maker and every type of heating system at moderate cost, with all the advantages which were developed for larger buildings.

In thinking of the Moduflow system as applied to a house, it should be pointed out that the system divides itself into two classifications—one a simple application for existing homes as well as new ones—the other for new homes where provision can be made during construction for certain additional features and refinements.

There are several methods of accomplishing Moduflow. In the first, or Reset method, the thermostat is, in effect, moved down into the heating system and called a temperature controller. Now, it will govern the heating medium, rather than the air in the room, and thus, the heating medium can be controlled within a range of a few degrees. Then a thermostat is placed in the room to measure the heat loss of the house; the thermostat actuates a motor which operates the temperature setting of the controller. Thus, whenever the temperature upstairs drops a fraction of a degree, the motor starts raising the setting of the controller, and vice versa, whenever the temperature rises in the room. Since it is impractical to put all this mechanism inside the heating plant, it is placed on a panel nearby. All that is necessary in the actual heating system is a temperature bulb placed in a warm air duct or radiator, where it can report the temperature of the heating medium to the temperature controller by remote control. Moreover, "Da-Nite" features can be incorporated.

The second, or By-Pass method, is equally adaptable to warm air or hot water. The by-pass system for hot water is accomplished by mixing the cooler return water with the hot water to the required temperature; the circulator must operate continuously in order to keep a steady flow of water through the system. In the By-Pass method heat loss is measured by a modulating thermostat. When the house needs more heat the thermostat sends a message to the mixing valve motor and the motor opens the valve to a new position for cooler or warmer water. The temperature of the water in the boiler is controlled by two aquastats. When no heat is required, an auxiliary switch stops the circulator.

The By-Pass method in a forced warm air system requires, first, that the furnace must be equipped with a duct which can by-pass the return air, and secondly, that there must be a set of mixing dampers, one a by-pass damper, to control the amount of unheated air, and the other a heated air damper to control the amount of unheated air, and the other a heated-air damper to control the amount of heated air going to the house. This set of mixing dampers controls the temperature of the air going to the house by controlling the ratio of heated to unheated air. The mixing dampers are operated by a reversible motor, and the motor in turn is controlled by a room thermostat. A blower operates constantly, so long as the house needs heat at all. A conventional airstat may be used in the bonnet to keep the bonnet temperature constant. However, the efficiency of the system can be increased by installing two airstats—one which will maintain a bonnet temperature of 170°, the other about 120°. The low-limit airstat controls the burner except when the heated air damper is nearly wide open, at which time the high-limit takes control. When the demand for heat decreases until the heated air damper closes about halfway, the low-limit airstat again takes control. An auxiliary switch turns off the burner and fan when the heated-air damper is nearly closed. This damper never completely closes, because it is important that there be some air circulation through the furnace to prevent overheating.

Since neither the Reset nor the By-Pass method of control applies to steam, the third, or Modulating Valve method, is designed especially for two-pipe steam; this method is the simplest to explain. Basically it works like this: first, a Pressuretrol maintains a constant steam pressure, and second, a modulating valve in the main steam line is controlled by a room thermostat. Whenever more heat is needed the thermostat moves the valve to a new position, allowing more steam to reach the radiators and vice versa. An auxiliary switch on the modulating valve may be used to stop the burner and allow the steam pressure to drop to zero when the valve is completely closed.

Sectional Moduflow Heating is most adaptable to a new home, in the plan stage or in its early construction. In most cases the same heating plant, burner, and controls will be satisfactory, with only the addition of the Moduflow Controls for each section, and some piping or ducts. Whether the heating system be warm air, hot water, or steam, the application is the same. Moreover, zoning, modulation, continuous flow of heat, more sensitive instruments, better furnaces and boilers, better construction and better insulation are not the only improvements to expect and demand be incorporated in the plans now being made for a new home or for the modernization of an existing one. In addition, outside compensators which will continually adjust the limit controls of the domestic furnace or boiler, depending on climatic conditions, will become commonly used. This device, nothing more than a remote bulb exposed to outside weather, will automatically raise and lower the high limit of the heating unit temperatures. As the heating season progresses and the thermometer records lower and lower temperatures, the outside bulb will raise the limit control in exact proportion to the amount of heat required to provide temperatures at a selected level. Likewise, as the weather becomes warmer, the limit control will be lowered. Similarly, if the home is equipped with an air-conditioning system, and many will be, it can be operated from similar controls, so that summer or winter, rain or snow, the home will be livable at the exact climate selected.

Finally, as a Sales Promotion Manager, I would be remiss in my duty and my concept of the purpose of this conference if these remarks were not concluded with a thought on merchandising, addressed particularly to those of you in the heating industry.

We are entering the greatest selling-sales promotional era in the history of our country. We will be engaged in the greatest competitive struggle for the consumer's dollar that we have ever known. It will be the smart manufacturer, the smart salesman, the smart merchandiser, who will win. The markets in heating are unlimited. The American consumer has been made and *is* comfort conscious. We also need to think in terms of obsolescence, much the same as last year's model in a hat, or car, or many other things we can mention that become obsolete, out of date, and therefore less to be desired.

K. C. Richmond gave us the facts and figures in his masterful paper—enough to think about for a decade. But as that was his subject, I will not elaborate except to say this: there is gold in "them thar hills" if we will aggressively, courageously, and imaginatively merchandise our wares by—

1. Uncovering dissatisfaction with the old.
2. Building and creating desire for the new.
3. Stimulating all directly or indirectly connected with our industry to the great new possibilities.
4. Making the heating system the most important item in home construction.
5. Getting a larger share of the home-builder's dollar for comfort heating . . . the better to enjoy the luxuries of home.

Yes, better heating will be the demand of the future. Americans will want better heating, just as they will want all other things that are waiting for them in the near future. They are going to expect and demand domestic heating systems as modern as their television sets or family airplanes. It is up to us to satisfy that want.

DISCUSSION

Henry F. Hebley presiding

L. W. HOUSEHOLDER[1]: I certainly want to congratulate Mr. Warmee on an excellent delivery of what to expect in the future. I agree that the heating of homes hasn't received enough attention and particularly our home heating systems haven't received enough attention from the heating people on the control end.

For instance, we get into the problem of service water in the home. We want to heat with one unit. In the winter time we can control the temperature of the service water very accurately by already developed control valves. In the summer, however, we need no heat in the home, but we do need hot water when we come in dirty from hard work, perspiring, for that is when hot water is needed. Can we heat the water with the furnace the same as we did in the winter time and not over-heat the house? You have a valve on your heating system which cuts it off in the summer; this is a very simple operation and the results are fairly satisfactory.

We have agreed that it takes about one-half pound of fuel an hour to furnish service hot water in a small home. We are faced with the problem of converting our main heating unit, which heated the entire house in winter and probably burned 30-40 pounds of fuel per hour, to burn one-half pound per hour of coal in order to furnish sufficient hot water for summer use; yet we don't have out-fire controls. There are serious engineering problems which must be solved or we are going to have duplication of heating equipment in all of our small homes, which means unnecessary expense.

Manufacturers are directly faced by the problem today. Many are making desperate efforts to solve it. There are one or two controls on the market today that will control a coal stoker and hold the fire on a feed rate of one-half pound of coal per hour, which rate gives plenty of heat for water heating. These will be on the market probably in 1946-47.

The big apartment houses, the hotels, the office buildings, etc., do not present a problem. Such organizations can afford to spend money for control panels and various controls in separate rooms. Our big heating problem is to get a cheap, uniform supply of heat and service water from one source of heat in a home; and I hope our control engineers of the country will spend a good bit of time trying to develop that sort of control whether it be for an oil furnace, a gas furnace or a coal furnace. I think we are rapidly coming to complete heating units which will give all heat requirements from one unit in the basement.

DISCUSSER FROM FLOOR: I would say Mr. Warmee doesn't have the consumer point of view. I am talking about homes to be built in the next few years. I think that the heating industry must take the example of the appliance industry of the country—refrigerators, electric stoves, coffee makers, etc. You can press a button on that type of thing, you don't have to watch it. The control industry has to make a furnace work the same way.

DISCUSSER FROM FLOOR: I think technically minded people agree that the direction of progress is to investigate the elaborate types of control. I would like to second the feeling of the gentleman who discussed the paper and that is from the standpoint of the stoker industry. This industry has low degree of saturation because of the high costs. We will have to find ways to reduce the costs of domestic stokers to have them used more widely. The control people can help on this end of that program.

You must not reduce the costs of stokers so that you get into low quality, inefficient, or unsatisfactory units. You have to reduce the cost to the consumer.

W. D. LEINBACH[2]: My experience with domestic hot water is interesting. I have

[1] President, Whiteman and Company, Inc., Indiana, Pa.

[2] President, Milton Machine Works, Milton, Pa.

a forced hot-water circulating heating system which was originally installed with a large size tankless heater. There are five in our family—two small children and three adults. I found that in many cases when I wanted to take a bath at the time my wife was washing clothes in the basement and our housekeeper was washing dishes in the kitchen, there never was a sufficient supply of hot water, and this happened frequently. I, accordingly, installed in series with the tankless heater a 30-gallon storage tank with circulator, control, and mixing valve, and raised the temperature of the hot water supply about ten degrees. We can now tap from all three faucets for a considerable length of time without inconvenience.

P. L. GROSS[3]: Our friend from Coal-Heat wondered if anthracite had been mentioned in the last few days. I don't know why it hasn't. There are many things in our anthracite not in some of the other coals. Better look into it.

On the question of hot water. I have operated for the past three years through the summer for domestic hot water with an aquastat. I am operating now with time control. I run it for one and one-half minutes an hour all through the summer. We have three children in the family and we have sufficient hot water at all times. Incidentally, I have 35-pound stoker. Figure out the fuel consumption and cost.

[3] Coal-O-Matic Stoker Co., Trucksville, Pa.

Trends in Heating Service and Fuel Engineering Activities

By J. E. Tobey*

In general, there is nothing wrong with the domestic coal business that some revolutionary new equipment will not cure. Imagine what a tremendous impetus this business would have from the advent of a competitively priced, compact, fully automatic coal-burning heating unit for new housing. Coal dealers everywhere would take it to architects and speculative builders and see to it that whole additions of new homes were equipped with it. The new homes of today are the old homes of tomorrow, and the coal industry must serve this market.

The advent of the conversion type stoker about 20 years ago gave domestic coal its greatest burning appliance. Consistently improved, it has to date converted a million heating plants from hand firing and unquestionably has retained many customers for coal. It would seem that this stoker should now emerge from the specialty sales category and enter that of popular or public acceptance. Higher demand will mean lower prices for this machine and millions of additional heating plants should be converted to this method of firing. The reconversion of the small stoker industry following the war is reflected in the U. S. Department of Commerce figures showing production for the first nine months of 1945 compared with the same period in 1944. The figures are: 45,045 Class 1 stokers—1945, as against 751 Class 1 stokers for the same period in 1944. Production should accelerate rapidly in this aggressive industry.

Everyone in the coal business is familiar with the tremendous success of the revolutionary magazine bituminous heater which came on the market five or six years ago. More than a million of these heaters have been sold nation-wide. The coal industry is aware today as never before of the tremendous stove coal market.

It is believed that we will look back on the post-war period as one in which there was great activity in experimental development of coal-burning equipment, where a state of flux existed in which many avenues were traversed in search of best means and methods to accomplish automatic and semi-automatic coal utilization in the domestic field. Never in history have so many organizations been engaged in research and experimental development of better coal-burning equipment. Never has the coal industry and its allies risen to such heights of realism in approaching solutions to the many problems of coal utilization as today. Never before have so many engineers, fuel technologists, research facilities and dollars been employed in the development of better coal-burning equipment. We purposely put people first, because brains are the priceless ingredient in the above formula for success. Out of the minds of these people most certainly will come ideas and principles of design of a revolutionary nature which will set the utilization of coal on a higher plane.

Much progress has been made in the past five years in all experimental laboratories engaged in coal research in spite of the serious war manpower shortage. Right here at Penn State the Division of Fuel Technology has, among other important developments, made a single contribution to the solution of the problem of burning strongly coking coals in small stokers. One of the most serious needs in the coal industry at

* Director, Fairmont Coal Bureau, 122 East 42d Street, New York, N. Y., Chairman, Technical Advisory Board, Bituminous Coal Research, Inc.

this time is for the widening of the range of coals which can be used in domestic stokers. Proof of this need lies in the fact that a comparatively small percentage of national sales of bituminous stokers has occurred in the State of Pennsylvania. Many of the high quality, strongly coking coals of this State have not been adaptable to the small stoker.

Without attempting to cover all of the territory, it is well to mention other research activities to illustrate the progress being made to improve the utilization of domestic coal.

The University of Illinois is making a promising contribution in what is known as the Fellows Heating Unit—a magazine type smokeless furnace. It is understood that the Lennox Furnace Company is cooperating in the building of test models.

The Williamson Heater Company is perfecting another revolutionary type of furnace whose magazine holds 700 pounds of coal, or about a week's supply in normal winter weather. It is smokeless in operation.

The Locke Stove Company is reported to have developed a new radiant type stove and has improved its already famous "Warm Morning" model.

Less specific, but promising, are the reports of some small stoker manufacturers that, as soon as the backlog of orders is filled for present models, they will bring out new designs which promise to raise the art of coal burning to a new level. They also feel that the bituminous, fully automatic stoker, which began to make its appearance before the war, will have a gradual but consistent development. In this connection, great credit is due the Pocahontas Fuel Company for its vision and resourcefulness in developing the O-P fully automatic, ash-removal stoker and the highly efficient forced-circulation warm air heating unit designed for combination with this stoker.

The Koppers Stoker Coal Research Laboratory, sponsored by Koppers Coal Division, Eastern Gas and Fuel Associates, is making excellent progress in studying the combustion behavior of various coals and coal characteristics. This laboratory has made several most valuable contributions in the way of technical papers and motion picture combustion studies. (Reference: "Coke Formation in Domestic Stokers," by Charles H. Sawyer and Walter Knox—AIME Coal Division Transactions, Vol. 157—1944.)

Of more fundamental nature, the studies at the Carnegie Tech. Coal Research Laboratory on the constituents of coal and the effects of heating and combustion on them under controlled conditions are yielding information which will be of great value in combustion equipment design.

The greatly expanded program of Bituminous Coal Research, Inc., will be treated very briefly here because published reports are available on most of the work in BCR Bulletins.[2] This comprehensive program, calling for the expenditure of a minimum of two and one-half million dollars in five years, was launched in the fall of 1943. It embraces research work in eleven different categories which are subdivided into approximately 100 separate projects. B.C.R. has industry-wide support and its affairs are under the supervision of a President and a Board of Directors composed of fifteen prominent and aggressive coal and railroad executives selected from sponsoring companies.

The actual detailed planning of projects and supervision of the research work come under the direction of the Technical Advisory Board, which is composed of 37 well-qualified fuel engineers of sponsoring companies. This Board is also divided into project committees. The staff at the B.C.R. headquarters in Pittsburgh includes a director, an assistant director, a public relations man, and technical and office assistants.

B.C.R. at the present time is sponsoring research work at Battelle Memorial Institute, Carnegie Institute of Technology, and West Virginia University, and is cooperating with many other research organizations. Manpower was scarce during the war, but now the staffs of technologists and project engineers are being rapidly built up. Much work has been completed and other work is in progress at Battelle Memorial Institute on the following domestic projects:

1. Smokeless magazine stoves and furnaces.
2. Residential stokers.
3. Smokeless magazine type domestic hot water heater.

[2] A short summary of this work is contained in the author's paper, "New Developments in Home Heating Equipment," presented before the Ohio Coal Conference, Columbus, Ohio, September 20, 1945.

4. Smokeless coal-fired kitchen range.
5. Studies on district and central heating systems.
6. Dustless treatment of coal.
7. Sizing of coals for residential stokers.
8. Rating and testing of warm air furnaces.
9. Complete gasification of coal.

EDUCATIONAL WORK

In keeping with the accelerated interest in equipment development, there will naturally be a step-up in the educational activities in the domestic field, and fortunately so, for many more technical aspects will be involved in furnishing the public greater heating satisfaction. Before the war increasing progress was being made along educational lines. Coal and stoker schools, institutes, and fuel engineering conferences were being held in cities throughout the country. Special courses in fuels and combustion were established in educational institutions. Technical societies were sponsoring papers on the utilization of coal in modern domestic equipment. Participating actively in all of these organized activities were coal retailers, wholesalers, operators, fuel and research engineers, engineering instructors, fuel technologists, representatives of railroads and coal trade magazines, and equipment manufacturers. Local and state retail associations were doing more educational work among their members than ever before. Increasing in prominence also were coal and equipment exhibitions, newspaper and magazine advertising and publicity, and retail dealer aids in the form of bulletins, house organs, pamphlets and charts.

Appalachian Coals, Inc., has made substantial contributions by helping organize stoker schools and heating institutes, and through the preparation of booklets, pamphlets, and other literature as aids to retailers and, indirectly, to domestic consumers.

Better Home Heating, Inc., was organized several years before the war to improve, as its name implies, the heating of homes with coal. Its accomplishments have been outstanding and it has a pattern of organization and procedure which could be widely adopted.

Bituminous Coal Institute, the Industry's newest organization, is laying firm groundwork to create a greater public demand for coal heat. It is doing an excellent job in public relations and for the first time the long inarticulate coal industry is given an official champion. B.C.I. has sponsored several successful exhibitions and radio programs; its excellent newsreels publicizing coal have been enjoyed by the movie public; millions have read its releases, and many of the recent book and magazine stories have been inspired by this aggressive organization.

The war is over, and this Housing and Heating Conference sponsored by The Pennsylvania State College, Division of Fuel Technology, to our best knowledge, is the first of what will surely be an endless progression of educational activities in behalf of the coal industry, its allies, and coal users. This famous school is to be congratulated on its vision and foresight in sponsoring this important meeting. The need will be greater than ever before for better-trained personnel in all phases of the domestic coal business, including the merchandising of automatic coal heating. The need will be greater for stronger and better informed national, state, and local retail organizations. Coal operators, wholesalers and retailers should work together as a family, for there is a big over-all cooperative job to be done in maintaining coal's competitive position. Large sales organizations and coal bureaus should become clearing houses for information which will be of greatest value to those on the domestic firing line. Many more capable fuel engineers should be employed to help solve the increasing technical problems incident to the modern use of coal, and to do educational work.

In reviewing the activities of the Bituminous Coal Industry to improve the acceptance and utilization of its products in the domestic field alone, one is astounded at the magnitude of these efforts. It would appear, in this large, widespread industry, made up of many thousands of various units that, as time goes on, promotional efforts should have the benefit of more centralized planning and direction.

It is of immediate importance that the best possible tools and greater recognition be given the great army of salesmen who will soon be setting forth to meet the keenest competition this Coal Industry has ever seen.

DISCUSSION

J. H. Kerrick presiding

E. R. KAISER[1]: The other day I mentioned something about district heating. I was told this was the time to bring it up.

I would like to give the group the benefit of studies which Battelle has made, but not yet published. We started with the proposition that we wanted to give the customer completely automatic heat. Several things could be done, such as converting the coal to gas and piping it as manufactured gas is now sent out, or installation of a stoker unit for which the dealer would deliver coal and take away the ashes. These would be approaches to the problem.

There is one other which had been started years ago and is quite successful in heating downtown areas; namely, the central heating plant. As we delved into it we found there were central heating units heating residential groups in Pittsburgh, Cincinnati, and other cities.

We figured piping costs with the result that the cost of the whole operation would be too high. We had no data to decide whether this was true. Battelle tried to make impartial studies and consider all costs, taking a plan of houses. Groups of 41, 81, and 121 houses were connected up to one central heating plant and the costs compared with those for individually fired homes.

With central heating, the houses wouldn't need chimneys and coal bins; consequently, the investment cost for heating plant would be lower. The cost of the heating plant, the cost of fuel at Columbus rates, and all costs, even insurance, between a house with a furnace and one heated with the central plant were considered. The study was finished and the results condensed. After a résumé of figures quoted from the results of the study, you may not agree with certain allowances made for this or that; Battelle tried to be conservative.

It shows that on a housing development where the pipes are laid in the ground at the time of the opening of the development, you can heat groups of houses (40, 80, or more) with a central heating plant and do the job cheaper than with individually fired units. We may now be starting a trend that will become very significant where large groups of houses are put up at the same time. Costs will probably go up if we try to lay pipes in an established district, but that is worth consideration.

E. E. FINN[2]: I have nothing to add to what Mr. Tobey said relative to prospective consumers of solid fuels. The program of Anthracite Industries is very similar to that described for the Bituminous Coal Industry.

However, as Mr. Tobey and I were associated as consultants for fuel conservation, I know that he will agree with me that we have serious engineering problems with present users of solid fuels. It is particularly important at this time because consumers are at the crossroads and want to know which way to go.

During a fuel conservation program on which I was representing solid fuels, I had occasion to be on the same program with a research engineer for an oil company; he spoke relative to conservation of oil and gas. I admitted frankly that fuels were not in some instances being as well prepared as prior to the war, because of pushing preparation machinery beyond its capacity. The oil engineer, in answer to the question as to the analysis of No. 5 oil, stated that all grades of oil are made on a typewriter today. Users of a fuel were prone to think that they would have better results were they using a competitive fuel in spite of the fact that all fuels had gone to war.

We have a service job to do. The condition of existing equipment is not as good as it should be.

[1] Assistant Director of Research, Bituminous Coal Research, Inc., Pittsburgh, Pa.

[2] Consulting Engineer, The Anthracite Industries, Inc., Primos, Pennsylvania.

Furthermore, manpower leaves a lot to be desired because men have changed to better-paying jobs. I believe, therefore, that we have an educational program to perform along with service to our existing customers to help them to obtain the results which they feel they have a right to expect. In this connection, there appears to be a job which the universities should do. For several years Columbia has offered a custodian engineers course, and I have participated in this course by lecturing on solid fuels. From attendance at this course, as well as the various lectures on conservation, I learned that many firemen and engineers are desirous of obtaining additional training on the subject of combustion. We should have throughout this country a large number of strategically located universities which will provide a combustion course so that engineers, firemen, etc., could get the training which they desired. We are receiving many requests for names of schools where the retail coal dealers' employees can be trained.

As an example, last week we had a letter from a man in Canada who expects to have his son take over the business. He asked where he could get technical training so as to be in a position to do a complete heating job, including equipment as well as fuel. Can we promote some type of combustion training in connection with short courses in universities? Alfred University in New York includes in their curriculum a course on heating and air conditioning. We need more such schools and I think all universities should give consideration to this vital need.

W. L. BARTEL[3]: The paper of Tobey's was fine in every respect and I was especially interested in the remarks which followed by Kaiser.

Insofar as Kaiser's statement that the city of Virginia, Minnesota, was almost completely heated by Central or District Heating, I wish to report that the entire city is heated by steam from a central source. Every home, store, church, etc., is supplied with steam through a network of underground piping. They seem to be doing very well from all the reports we have had from them.

With respect to the report of the Battelle Memorial Institute study which Kaiser presented, I can vouch that this study is not guesswork; our company actually bid the underground piping on this project. It was expressly interesting to note that Battelle has considered both hot water and steam as the heating medium, particularly since the European trend, prior to the war, was in the direction of hot water, while our own cities have utilized high-pressure steam in District Heating Systems.

A very good example of a Central Heating split system is the installation at Pittsburgh's Terrace Village Housing Project. A central plant generates high-pressure steam which is distributed to six converting stations which in turn distribute hot water to all the buildings on the plot. Data and costs on operation bear this out as one of the better Central Heating Systems in this country.

DISCUSSER FROM FLOOR: How many buildings in the Pittsburgh Project?

W. L. BARTEL: There are 83 buildings—1851 living suites. Quite a good size project.

DISCUSSER FROM FLOOR: Are these controlled by thermostatic control in each house?

W. L. BARTEL: Temperatures of hot-water heating are controlled at the six converting stations.

A. W. GAUGER[4]: Referring to the point raised by Mr. Finn, our Extension Division has classes all over the State of Pennsylvania in the various fields of work of the School of Mineral Industries. Anytime any group wishes to make arrangements for courses of that character I know it will receive cooperation from our extension services.

Concerning stoker difficulties, I would say there are insufficient engineers trained in fuels and I can speak freely about this because I was instrumental in inaugurating the course in fuel technology at Penn State.

I would like to speak about this matter of research.

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[3] Public Relations Director, The Ric-Wil Co., Cleveland, Ohio.

[4] Director, Mineral Industries Experiment Station, The Pennsylvania State College.

I have been engaged in fuel research for some 30 years. In its essence the present equipment resulted when some man who didn't like smoke in his cave or tepee put his fire in a container with a stack going out through a hole and that is practically what we have now. If I were starting over again, I would get some men who never fired anything, who were well-trained in physics, chemistry, and physical chemistry and who knew the properties of fuels, heat transfer and heat transfer materials, lock them in a room, and tell them the problem was to start with this fuel and come out with hot water, warmth in the room proper, humidity, and a cooling system in the summer time. And I think in the end we would have a device that wouldn't look like anything we have ever seen, but would solve a lot of difficulties.

Preparation of Coal for Domestic Use

By David R. Mitchell *

PREPARATION of coal is as old as coal mining. Originally preparation consisted of crude methods of picking out refuse and hand selection of sizes. As our industrial civilization evolved, consumer requirements became increasingly complex and forced such coal preparation procedures on the coal mining industry as mechanical cleaning, sizing, dustless treatment, and blending.

At the present time coal preparation for the domestic consumer is somewhat of a paradox. There are consuming areas into which the coal that is moving is clean, accurately sized, and dustless. There are other areas where coal is furnished with little or no preparation. Similarly, certain producing regions have specialized in catering to the domestic market and furnish carefully prepared coal that can be guaranteed to give satisfaction in the burning equipment for which it was prepared. Most of the coal mine operators in these regions have standardized on certain preparation practices and methods of inspection so that the coal marketed by them gives satisfaction in the particular type of equipment for which it was tailored. In other producing regions little attention is given to the domestic market. Although certain regions have been outstanding in preparing coal for the domestic market, there are operators in other regions who are, likewise, doing an excellent job of preparing coal for the domestic market.

PREPARATION AND MARKETING

Most of the coal prepared for the domestic market is sold by the coal producer to the local coal merchant who in turn distributes it in comparatively small amounts to the consumer's bin. Thus, the coal merchant is in a favorable position on account of personal contacts—if he takes the trouble—to determine the requirements of this market.

During the war years it has been possible for the coal mining companies to sell all of their output by casual methods. As reconversion takes place and we move to a seller's instead of a buyer's market, increasing attention must be given to consumer satisfaction which means more attention to preparation.

Modern marketing of coal is something more than selling. It implies the additional objective of promoting and guaranteeing customer satisfaction. It is becoming increasingly evident that coal must be sold subject to the same condition as any other commodity; namely, the consumer must be satisfied.

WHAT THE CONSUMER WANTS IN COAL AND COAL HEAT

Surveys have shown that above all else the home owner desires clean, quiet, trouble-free, automatic heat. Economy is secondary except that if the cost is too high, he will be receptive to using competitive fuels. In certain places heat service plans have been very successful. All of these successful plans have embraced the use of prepared coal of relatively higher cost to the consumer than other coals available in the community.

Coal burning equipment found in homes consists of hand-fired furnaces, stoker-fired furnaces, heating stoves, kitchen ranges, fireplaces, and hot water heaters. Each type and, frequently, each size of domestic coal burning equipment requires coal specially prepared as to size, size consist, and cleanliness for maximum economy and fuel satisfaction. It must be recognized that regardless of how good the furnace, stoker or other coal burning equipment may be, more

* Head, Department of Mineral Engineering, The Pennsylvania State College.

satisfactory results will be obtained with coal specially prepared to fit the equipment.

In many communities during the war, coal for domestic purposes was short. Those residing in homes were forced at times to use substitute coal, poorly prepared and off-grade. Shortages because of strikes created hardships in many instances, and at no time, particularly in the East, was the house dweller entirely free of the worry of getting coal. Furthermore, mismanagement by ration boards added to his woes.

In addition, during 1941-1942 many, as a patriotic move, changed from oil or gas to coal. As time passed, it was frequently observed that neighbors, not nearly so patriotic and self-sacrificing, who kept their oil burners, were actually better off than those depending on coal. All this has left a bad taste, with the result that many are changing back to oil or gas, and others are planning on doing so. Now is the time when coal merchants and coal companies should be advertising the benefits of coal heat and making every effort to keep their consumers satisfied. For example, proper attention to preparation will be a great help.

Just as one rotten apple in a bushel will soon cause all the apples to become rotten, so dirty, poorly prepared coal from a few "fly-by-night" mines in a producing area will soon give the whole area a bad name. Trade marking and standardization of preparation and inspection procedures are helpful in insuring quality products having a high degree of consumer acceptance. The domestic consumer wants coal, cleaned of impurities, carefully sized, and treated to make it dustless.

ANTHRACITE

Anthracite is the only natural fuel that is smokeless under all conditions of use. It is an ideal fuel for domestic purposes. Surveys have shown that approximately 80 per cent of the anthracite produced is used for space heating of homes, office buildings, schools, hospitals, and apartments and burned in hand-fired equipment. An increasing percentage of anthracite is used in automatic stokers and other automatic and semi-automatic coal burning equipment.

The anthracite industry did a magnificent job of preparing coal to standard specifications during the war years. Probably 95 per cent of the coal going to market was equal to or better than the established standards. Off-grade, poorly prepared coal was in the minority and originated at the so-called "fly-by-night" operations or "bootleg" mines.

No other coal producing region in the United States has such a high percentage of its output going to the domestic consumer; nor has any other producing region studied the domestic market as thoroughly or adopted such strict controls of preparation and marketing practices to insure consumer satisfaction.

All anthracite is mechanically cleaned and sized according to rigid specifications. Size and cleanliness are regulated by the Anthracite Committee functioning in collaboration with the Department of Commerce of the Commonwealth of Pennsylvania. The specifications include size control and oversize and undersize tolerance, as well as maximum impurity allowances of bone and slate. All car-lot shipments are sampled, tested, and inspected to determine whether the coal in each car meets these standards. Any condemned coal is re-run through the preparation plant.

Surveys show that there has been a considerable improvement in the average quality of anthracite shipped to market. A summary of two surveys made in 1923 and 1935 by the U. S. Bureau of Mines is given in Table 1.

TABLE 1. Average Ash Content of Anthracite; Size Designation in Inches

	Massachusetts Survey, 1923	*Preparation Plant Survey, 1935*
Egg (3¼ x 2$\frac{7}{16}$)	13.7	9.2
Stove (2$\frac{7}{16}$ x 1⅝)	13.7	9.3
Nut (1⅝ x 1$\frac{3}{16}$)	16.2	9.7
Pea (1$\frac{3}{16}$ x $\frac{9}{16}$)	15.6	11.3
Buckwheat ($\frac{9}{16}$ x $\frac{5}{16}$)	18.9	11.7

Although not included in the above surveys, similar improvements in the rice and barley sizes have been noted.

For domestic use almost all anthracite is purchased by size designation in accordance with the approved size specifications and purity standard of the Anthracite Committee. The size of coal best suited for any particular type of burning equipment depends on the size of the equipment and method of firing.

Dominant sizes in order of probable preference for specified uses are given in Table 2.

TABLE 2. Dominant Sizes of Anthracite

Equipment	Size
1. Hand-Fired Furnaces	1. Nut
	2. Stove
	3. Pea
	4. Egg
2. Space Heaters—stoves	1. Nut
3. Kitchen Ranges	1. Nut
	2. Pea
4. Hot Water Heaters—Large	1. Nut
Hot Water Heaters—Small	1. Pea
5. Fireplaces	1. Nut
	2. Stove
6. Stokers	1. Rice
	2. Buckwheat
	3. Special Stoker Size

BITUMINOUS COAL

There are no comparable standards for bituminous coal as for anthracite. The sizes made vary from mine to mine and from district to district. Variations abound as to coal sizes recommended for various types of equipment and for the various sizes of equipment. Some of these variations are due to differences in the rank of coal—low, medium, and high volatile. In general, the probable dominant sizes for domestic coal-burning equipment are given in Table 3.

TABLE 3. Dominant Sizes of Bituminous Coal, in Inches and Mesh

Equipment	Size
1. Hand-Fired Furnaces	Egg and Nut
	(1) 6 x 4
	(2) 6 x 3
	(3) 4 x 2
	(4) 3 x 2
	(5) 3 x 1¼
	(6) 2 x 1¼
2. Space Heaters—stoves	Nut
	(1) 2 x 1¼
	Stove
	(1) 1¼ x ¾
3. Kitchen Ranges	Nut
	(1) 1¼ x ¾
	(2) 2 x 1¼
4. Waterheaters (Little used)	Nut
	(1) 1¼ x ¾
5. Fireplaces (Little used)	Egg
	(1) 4 x 2
6. Stokers	Domestic Stoker
	(1) 1 x ¼
	(2) ¾ x 10-M
	(3) 1¼ x ⅜
	(4) ⅜ x 10-M

Underfeed stokers require specially prepared coal for best results; a closely sized small coal gives excellent results. A 1- by ¼-inch size is usually made for the household stoker market; ¾-inch by 10-mesh is one of the best sizes; a 5/16-inch by 10-mesh size is giving good results in the Middle West. In any case the top size should not exceed 1-inch and the coal should not contain a high percentage of minus 10-mesh sizes.

DOMESTIC COKE

Domestic coke should contain a small per cent of volatile matter. Ash should not exceed 10 per cent. Sizes recommended for domestic use are nut (2 x 1¼) and range (1¼ x ⅞).

DISCUSSION

J. H. Kerrick presiding

C. M. STULL[1]: The problem of coal preparation, it seems to me, is divided into two very distinct parts: (1), the screening of the coal and (2), the cleaning of the coal. I have no "crow to pick" with those who advocate clean coal, but I do feel that

[1] Lt. Comdr., U.S.N.R., Off. of the Chief of Engineers, Wash., D.C.

some improvements could be made in the screening of coal.

I have a rather radical idea with which some bituminous men may not agree. I believe that in the preparation (screening) of coal, entirely too many sizes are made. For example, in Illinois as many as 25 or 30 different sizes are produced. The production of this multitude of sizes adds greatly to the cost of producing coal, and in my opinion adds little to the salability of the product.

It appears to me that in the preparation of coal at the mine, all but a maximum of four or five sizes could be eliminated. These sizes could be mine run, egg, stove or nut, nut and slack, and slack. The research on domestic type stokers should be concentrated on the design of a domestic stoker which will burn the slack sizes. The coal for domestic stokers should be a dustproofed slack size. If the stoker will burn this size and no dust accompanies the delivery, the consumer will certainly use it. The domestic stoker in the Penn State laboratory was burning a slack coal, and a small size slack at that. The domestic stoker should not be so dependent upon special coals that each piece must be wrapped in cellophane. The whole thought, which has been common in stoker design in the past, has been more toward the design of equipment that would not operate satisfactorily unless a very special coal was delivered to the stoker. This, in my opinion, is not good practice, and all efforts should be directed toward the design of a stoker which will burn any coal delivered to it. We are certainly reaching this point in industrial stoker design with the advent of the combination spreader-chain grate stoker.

My idea is reduce the number of sizes of coal produced and design equipment which will be flexible in the type and size of coal that can be burned efficiently.

E. R. HINTZ[2]: In commenting on anything Mr. Mitchell said, I would like it understood that I can speak only from the anthracite standpoint.

I would like to mention—our chairman and others here probably will sympathize with me—the question of dirty coal. We have had unusual amounts of this during the war, thanks to the causes cited by Messrs. Mitchell and Finn. I am concerned with getting rid of that stuff. When we get back to normal market I feel something must be done to eliminate dirty coal, which has caused a great deal of friction. Obviously, the good producers are in a bad position to do anything about it, because it is the marginal producers who turn out poor coal. The marginal retailer is always willing to buy this stuff. Is the answer legislation, or control within the industry? I do think something will have to be done because the disgruntled customer makes a prospect for competitive fuels.

J. H. KERRICK: I can sympathize with you on the point of dirty coal. We feel sometimes that our preparation is off until we attend meetings like this. I do think you are absolutely correct in stating that it is the marginal operators who are largely responsible for the off-grading of coal.

Our company and all line companies, as we call them in the Anthracite Industry, are doing everything in our power to improve the quality. I think we are able to stand any examination of facilities and preparation of coal for the market.

In many instances in the field we run into splendid preparations, but the preparation is spoiled by the handling of the coal at the terminal point. We have found many cases where the coal has been dropped as much as 18-20 feet on concrete and then the dealer wants to know why the coal varies so much in size. Some dealers are screening coal to offset degradation. There are those who don't. I do think that during the war the Solid Fuels Administration has been doing a good job in apprehending those deliberately selling off-grade products to the public.

C. S. BRENNER[3]: I think this subject has been pretty well covered. However, I would like to emphasize one point that Mr. Mitchell brought out about an operator in Illinois who sized coal apparently like his neighboring operators, but couldn't sell his coal because of its different burning characteristics. I think perhaps the difference in burning char-

[2] Executive Secretary, Pennsylvania Retail Coal Merchants' Association, Reading, Pa.

[3] Sales Manager, Butler Consolidated Coal Co., Wildwood, Pa.

acteristics between the different seams is one reason why we, in the Bituminous Coal Fields, are not able to achieve such uniformity of sizes as they do in the Anthracite Field.

I've heard a lot of argument between high-volatile coal producers about another point that the Commander mentioned. Most of the domestic stokers have screw conveyors which, in carrying coal to the retort, do a lot of crushing. Is it necessary, therefore, to spend so much effort and expense in screening domestic stoker coals so carefully? I would like to hear someone say something about this thought.

D. R. MITCHELL: At the time when the household stoker was built, some of the companies found that by taking the fine dust out of the coal they could make a very fine domestic stoker fuel. Thus, they were taking a product of lower price value and making a product that could demand a fancy price.

I know of a case where a coal operating group moved into one of our most competitive cities. They had coal which brought the lowest price in the industrial market but was suitable for domestic stokers. They obtained the help of the dealers in that city to get stokers sold. Orders for coal came in from householders and the coal went out to them at one dollar more a ton than it would have to industry. There was no hesitancy in asking one dollar more a ton and they got it.

J. C. MILES[4]: Concerning the problem of clean coal, I, personally, have never seen clean coal. You can wash it, dedust it, oil it, wet it, etc., but it is still dirty coal. Apparently, there is a great possibility for packaged or bagged coal to be used in weights of possibly 10 to 50 pounds. The paper industry and the coal people might well consider this, even for stoker use.

During some experiments with packaged coal in 25-pound sacks, the coal was carried through the parlor and over the carpet to the heating stove. The bag and all was lifted into the stove and burned. This was the only clean form of coal I have ever worked with.

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4 Assistant Professor of Mechanical Engineering, University of Illinois, Urbana, Ill.

Current Developments in Radiant Heating

By C. A. Hawk, Jr. *

ALTHOUGH the subject of radiant heating is widely discussed in the heating industry today, it is a common experience to find that a certain amount of confusion and uncertainty surround the topic. This is unquestionably a logical condition; for notwithstanding that the history of the technique stretches back many years, the direct experience of most practicing heating men, whether engineer, contractor, or craftsman, is quite limited. Thus, the popular concept of the work is based to a large degree on hearsay, frequently of an uninformed character.

It is, therefore, this author's purpose to bring before this Conference an accurate report on current developments in the field of radiant heating. This report will concern itself entirely with practice and application rather than theory. When using the phrase "current developments," the scope of this report becomes automatically limited to a story of applications rather than products, because no new and unfamiliar products are employed in normal radiant heating work and none have been specifically necessary throughout the modern development of the technique.

It can safely be said that the modern development began about 40 years ago in England and the history of radiant heating since that time has been largely one of finding out just what a group of simple basic products could do when arranged in unorthodox patterns, that is, with regard to structural elements, to meet widely varying sets of conditions. To touch briefly on this group of elementary pieces of equipment, it is necessary to consider only a conventional steam or hot-water boiler, pipes to carry the heating medium, a pump to circulate the fluid if water is employed, and the necessary control devices. Any of the conventional boiler types have been and can be employed, regardless of whether they are fired with coal, oil, or gas. Water is the usual choice as the heating medium because of design and installation simplicity, and ease and smoothness of control. Conventional space heating controls have amply demonstrated that their performance is just as suitable to radiant heating systems as with any of the more conventional systems. The supplementary equipment, such as valves, vents, compression tanks, etc., normally found in wet-type heating systems will also be found in a radiant heating system.

The earliest true radiant heating system found so far in this country was installed in the floors of a two-story, four-room schoolhouse in a town which is now part of Gary, Indiana. This schoolhouse was built in 1909, and the heating system served in an unusually satisfactory manner for about 25 years. From this rather recent beginning, a high degree of ingenuity on the part of many independent heating men has developed the germ of the underlying physical principle into many applications and diversified fields. To illustrate the character of modern application and to report on how other heating designers are making use of this physical principle at the present time, the following case histories are cited.

An addition to a large textile mill recently completed in Canada is a good example of the application of the radiant heating system to meet specific requirements. A dye-house comprising part of this mill is roughly 100 by 125 feet in plan, with a 20-foot ceiling height to the underside of a flat concrete slab roof. The floor of this building is covered for perhaps 75 per cent of its area by large sunken dye vats. During operation of the dyeing process, the boiling water in the vats gives off more than enough heat and moisture to maintain comfort conditions in the space. The principle problem during these periods is to evacuate hot

* Engineering Service Department, A. M. Byers Company, Pittsburgh, Pa.

air and water vapor sufficiently fast to maintain comfort. During shut-down periods, it is necessary, however, to introduce some heat into the building to prevent freezing in a climate which frequently hits −30°F; the designing engineer elected to place radiant heating coils carrying hot water in the roof slab. In operation, experience has shown that the warming effect of these heating pipes prevents condensation on an otherwise cold ceiling surface and carries temperatures in the building at 40°F over weekends or other non-operative periods.

An adjoining building in this mill is devoted to weaving and spinning operations and contains two floors, each with a 15-foot ceiling, covering an area approximately 125 feet square. The owner's previous experience with other similar structures indicated that periodic and costly maintenance was required with conventional unit heaters. By turning to a floor-type radiant heating system on the first floor and a ceiling-type heating system on the second floor of this building, the maintenance charges were eliminated and a more uniform temperature and relative humidity could be maintained. To accurately convey the size and complexity of this installation, it should be noted that the total cost of these two buildings was approximately $300,000; the cost of the heating contract for the radiant heating system was approximately $23,000.

A much smaller but more widely based application for radiant heating systems is being uncovered in poultry-brooding operations; this applies equally to chickens, ducks, and turkeys. The author has recently investigated one very large application on Long Island devoted exclusively to the raising of that rare dinner-table treat, the famous Long Island duck. About two years ago one of the larger duck farmers on Long Island lost a large brooder house because of fire. When rebuilding it, a floor-type radiant heating system in the concrete floor slab was included. The results since that time have been so successful that seven other similar houses have been constructed and the new operation has radically changed the complexion of this operation. Before going farther it should be noted that the duck farming operation, as carried out on Long Island, is big business and, consequently, points which, otherwise, may seem minor take on considerable importance when it is realized that anyone of several of these farmers will ship one-quarter of a million ducks per year at about $2 per head. The brooder houses referred to measure approximately 30 by 150 feet, and will house approximately 7000 ducklings at one time. During a 10-week growing cycle, it was found that an average weight increase, winter and summer, of approximately one-half pound could be attributed to the more healthful conditions created by the radiant heating system. In addition, the maintenance of the proper floor surface, usually straw or woodchips, was made much simpler and considerable labor savings resulted. Of great, direct importance is the fact that the fire hazard in such structures has been almost entirely eliminated because of the construction of a central boiler plant and the elimination of many individual and sometimes unsafe heating devices located on the floor of the brooder houses.

During the war explosives manufacturers experimented with radiant-heated curing ovens with excellent results. Based on these experiments, a considerable number of these curing rooms, probably some 200, have since been constructed. During the curing operation, it is necessary to maintain a very exact temperature control in the neighborhood of 140°F and, at the same time, produce these temperatures with equipment which will be just as safe as it is economically possible to devise. The experiments referred to sought to establish the control accuracy available with floor, ceiling and wall types of heating coils. After rather exhaustive study, the floor type coil was selected, and has been generally used. Over an eight-hour operating cycle in extremely cold weather, it was possible to maintain 140°F in these buildings without varying more than 0.5°F from the thermostat setting. The obvious safety advantages inherent in complete concealment of all heating appliances are of course very desirable in such hazardous work.

Many municipal building programs at the present time contemplate the construction of new hospitals and mental institutions. In many of these institutions, radiant heating systems are being planned at the present time. Largely because of the complete concealment characteristic of radiant heating systems, it is possible to create much cleaner and safer environments for the patients and inmates of these institutions than has formerly been provided by other means.

Many automobile dealers and service establishments all over the country are seeking to rebuild or revamp their worn-out plants. Since a considerable experience backlog is available to demonstrate the significant advantages in comfort due to the use of radiant heating in such buildings, a great many systems of this type either have been installed, are under construction, or are being planned. In these days of more careful consideration of employees' working conditions, the excellent degree of comfort which radiant heating brings to such hard-to-heat buildings is exceedingly valuable. The installation of radiant heating systems in garages is not normally an intricate problem and, consequently, the installations are being made at reasonable figures.

In retail establishments the trend toward huge glass areas facing the traffic flow has brought with it additional headaches for heating men. However, the number of radiant heating installations in such structures is steadily increasing, because of its peculiar adaptability to the problems involved. The necessity for radiator or grill space at the bottom of windows is eliminated, along with the marked and uncomfortable down-drafts normally associated with glass areas.

These examples serve to illustrate a variety of applications and the "fringe" type of installation, but the interest of this Conference is to a large extent directed toward residential heating. In this field, the trend toward the use of the radiant system is very marked. The unusual degree of comfort produced, the almost unbelievable cleanliness, total concealment, the adaptability to "modern" architecture, and the freedom to do things with houses not previously considered practical—all add up to powerful reasons why this trend is likely to continue. A considerable amount of individual consumer acceptance is apparent, and it is interesting to note that this is the result of the inherent merit of the system rather than a promotional campaign. As far as is personally known to this author, no one has yet spent any appreciable sum to advance the cause of radiant heating with the general public. Nevertheless, a number of operative builders in various sections of the country are making rapid progress with radiant heating plans to be applied on a broad group scale. To give some examples of the number and scope of such plans, projects at the plan stage or under construction are under way for the following: 30 houses in Bangor, Maine; 40 in Pittsburgh, Pa.; 500 in Washington, D. C.; 300 in Houston, Texas; and 25 in Salt Lake City, Utah.

The progression toward the use of radiant heating has not been uniform and probably will not be. Any such basic change in common practice always has its fervent proponents and rabid opponents, with the majority of those concerned holding to a middle lane. Yet, each week brings increasing evidence that the use of the radiant heating system is becoming ever more widespread, and has taken up a permanent and sizeable place in the building industry. In the past the engineering of radiant heating systems has varied over a wide range from what might be called sound design to very elaborate and extravagant creations. The knowledge, ability, and experience of the individual designer has a great deal to do with this condition. Moreover, designing knowledge has so crystallized today that there is little reason for any important variation from one designer to another, and a good percentage of practicing heating men are capable of at least elementary design. Experience and inertia at the contractor level also has a lot to do with the progression of radiant heating in any given community. Most communities throughout the country, however, now have access to at least one competent contractor who can be counted on to do a thoroughly good radiant heating job at a reasonable figure. Various proponents of radiant heating systems have adopted different educational methods for both designers and contractors. The method currently being employed by one natural gas company is interesting—this firm is struggling hard to complete, within the next 90 days, a model house on the property of one of the builders in the community in order to assist in the education of architects, engineers, builders, and contractors.

Installation costs for radiant heating systems are worthy of some notice. Without going into detail on this point, it is sound to report for the record that a thoroughly good residential radiant heating installation need cost no more than any other good conventional system. When the designer and contractor have even a nodding acquaintance with the system, the ultimate installation cost will be found to be quite close to that for other systems. For example, a residential installation completed in Southeastern Virginia within the past 30 days ran to approximately $900, while a two-pipe hot-water radiator system for the same installation was bid at about $1100. In large work, radiant systems rather consistently cost less than other "high quality" systems, and in many instances, can be brought down very close to the cost of what might be termed minimum systems. For example, a 7000 square-foot garage in Salt Lake City included a radiant system which cost 10 per cent of the total structure, whereas the bid for unit heaters for the same building amounted to 9 per cent.

Operating costs on a comparative basis have not been established to the place where one can say that a radiant heating system will cost such-and-such a per cent less than fuel costs for the conventional system; however, the closely observed operation of hundreds of different radiant systems leads to the rather definite conclusion that sizeable fuel economics can be expected. This is normally estimated to be somewhere in the range of 20-30 per cent, but further comparative testing will be necessary before this value is definitely known.

In closing, the attention of the Conference is called to the presence of an "infant" idea which shows signs of growing into a very important device in modern building; the reference here is to the underground snow melting system. While this does not incorporate, to any appreciable degree, the transmission of heat by radiation, the fabricating and designing technique is somewhat related and, as a matter of fact, has its roots in the radiant heating development. Without going into the economics involved in such a system, it is sufficient to say that the removal of snow by heat appears to be very practical for any locality where an output of money is required for snow removal. Such applications can be found at airports, department stores, railroad passenger and freight platforms, industrial and residential driveways, etc. The initial cost is a rather sizable item, and can be roughly estimated for most communities at something between 30 and 50 cents per square foot of surface, depending on local conditions. Operating costs, however, are exceedingly low. The usual practice is to design for a melting rate of one inch of snow per hour. On the basis of coal of 12,000 Btu per pound at five dollars per ton, one inch of snow can be removed from one square foot of surface for approximately 0.003 cents. To put this cost another way, a six-inch snow fall on an airport runway 5000 feet long and 150 feet wide could be removed at a fuel cost of $135. This could be done in six hours' time, almost entirely automatically, and leave a perfectly dry, clean runway.

DISCUSSION

J. H. Kerrick presiding

W. L. BARTEL[1]: I think Mr. Hawk has given us a paper that is very worthy of this conference; however, he seems to have stolen much of the thunder from what I wanted to say about Radiant Heating.

Sometime ago one of his colleagues, George Cushing, wrote an article which appeared in many of the national publications in which he cited the airport of the future. He stated in his paper that the cost of radiant heating for the runways and apron would amount to 30 cents a square foot, which is in line with Mr. Hawk's statement. On a mile long runway, 200 feet wide, he reported the total cost of $316,000; however, he balances this off by the amount the airport must pay each winter for clearance of snow.

Also, mentioned was something of interest to all

[1] Public Relations Director, The Ric-Wil Co., Cleveland, Ohio.

coal men present. The example was a runway 1000 yards long and 100 feet wide. In order to clear the snow from that area by radiant heating, it would be necessary to burn 72 tons of coal every 24 hours. Gentlemen, that is certainly a market for the solid fuels people.

A. J. JOHNSON[2]: Are the pipes on snow melting systems drained when not used?

C. A. HAWK: The practice at the present time is to make use of a permanent anti-freeze. The system illustrated has used an anti-freeze solution for about five years. The system does not circulate during non-operating periods.

A. J. JOHNSON: How expensive is that?

C. A. HAWK: The anti-freeze for that drive way would cost about $15—a rough estimate—retail.

C. C. TYRRELL[3]: We have just finished a radiant heated floor in our laboratory addition. The reaction of the men to that type of heating is particularly good. They like the warm floor. Previously, the men in the shop had always placed boards on the concrete floor to stand on because of the cold floors.

The design in this installation is for an 80-degree floor temperature with zero temperature outside. The heating coil is one-inch pipe laid on about 13-inch centers on a 6-inch crushed stone fill, leveled, and then covered with four inches of concrete. So far our experience has been very pleasant even though we have had no zero days yet.

R. E. DALY[4]: Does that Cape Cod house have thermopane or ordinary glass?

C. A. HAWK: Thermopane.

R. E. DALY: What is the average wall temperature with the floor coil job?

C. A. HAWK: The study of wall temperatures is not as broad as it should be or will be before long. The air in a radiant-heated room is so very still that its effect on the temperature of the wall is apparently very different from that taking place in conventionally heated rooms.

R. E. DALY: What is the usual air temperature in these homes?

C. A. HAWK: Depending largely on the geometry of the room, a temperature of from 68-71°F is usually comfortable through the use of this heating system. In a large space like the garage, the temperature is closer to 65°F. People demonstrate diversities in preference on this point. We know of some houses operated as cool as 62-63 degrees, others at a level of 71-72 degrees, but never warmer.

A. V. OVERN[5]: I am interested in this subject in connection with heating of school buildings. I would like to ask if there is any difference in the economy of this system in very cold climates such as North Dakota? I heard a talk a few years ago by an architect and he said there was doubt whether it would be economical in cold climates.

C. A. HAWK: It is hard to tell on what information your earlier report was based. One of the very first accurate comparative studies made was made in a city in Denmark. In a school building in this city, there were 12 school rooms, all substantially the same. Six were heated with conventional radiators. Six were heated by a radiant system. The fuel consumed was carefully measured over a long period of time, and it was found that the radiant-heated rooms required about 30 per cent less fuel than the other rooms, even when the radiant-heated rooms were carried at full temperature over the weekends. The other six rooms were allowed to cool off.

The experience in this country seems to indicate about the same thing, although no exact comparative tests have been made. We have this result: users of all classes of building, garages, the army, private residences, institutions, without having identical structures to base findings on, all seem to feel that, space

[2] The Anthracite Industries, Inc., 101 Park Ave., New York 17, New York.

[3] Senior Mechanical Engineer, The Anthracite Industries, Inc., Laboratories, Primos, Pa.

[4] Manufacturing Department, American Radiator and Standard Sanitary Corp., Pittsburgh, Pa.

[5] Visiting Professor of Educational Administration, The Pennsylvania State College.

for space, they are doing a better heating job with less fuel than is normally the case.

C. H. SAWYER[6]: Are these coils installed in floor panels level or are they pitched to drain? Also do you have any information as to the likelihood of pipe failure in concrete panels, and if so what provision is there for repair?

C. A. HAWK: The answer to the first question is split because of the coil location in houses. If the boiler is in the basement, the coils are usually placed level because the drainage spot is in the basement. With the boiler on the first floor level, the coils are usually placed level, and either the supply or the return coil is pitched. This results in only partial drainage, but most engineers feel that it would be sufficient to prevent rupture from freezing.

The question of life of materials in concrete is one that takes a little thinking. As far as we know at the present time, there has never been a failure of a wrought-iron system. Moreover, in our houses we have no compunctions about placing piping materials, which are subject to a much more corrosive condition, behind perhaps the most costly surfaces in the house. Likewise, we have no hesitation about putting sewage lines beneath concrete floors in the basement, and they frequently have to come up to be repaired or replaced. We haven't introduced any new problems, but we have increased the danger from some old ones. This is the reason why it has always been recommended that these systems be designed and installed by competent people and be made of high quality materials throughout. It is the type of structural problem that is a little too dangerous to allow consideration of inferior products anywhere along the line, simply for the sake of saving a few dollars.

[6] Research Division, Koppers Company, Inc., Kearny, New Jersey.

Current Developments in Air Conditioning for Residences

By G. K. Marshall*

A DISCUSSION of current developments in almost anything today requires the utmost discretion, because we are all jealously guarding our design and development plans until the opportune moment when we can unveil our masterpieces to the waiting public and immediately command the market. Under such circumstances it is, of course, impossible to relate in detail the developments by General Electric Company. Instead, it is pertinent to discuss prewar equipment and methods, pointing out trends and improvements which, to those intimately acquainted with the field, seem to present the most logical fields of development.

First, let us examine the room air conditioner in Figure 1. This type of unit is General Electric's bid for mass acceptance of residential air conditioning, and all indications are that it will be successful. It is built in two types; namely, window units and floor units, which derive their names from the method of mounting. The window units are placed on the window sill and the floor units on the floor, as in Figure 2. The heat extracted from the room air is usually transferred to outside air that is circulated through the unit, hence the reason for locating the unit in or in front of a window. The moisture taken from the air is re-evaporated into this same outside air and is thus disposed of. This design eliminates the need for plumbing connections, and requires only an electrical connection which can be a simple plug not unlike the type used in plugging in a radio or floor lamp.

Water-cooled units have been made and may be continued. They involve the cost and difficulty of plumbing connections, but have the questionable advantage of not requiring an outside air connection and consequently can be located anywhere. These advantages are questionable because ventilation is a prime requisite of air conditioning, and while it can be obtained by slightly opening a window, it is more effective when provided by the air conditioner. The air conditioner provides positive ventilation al-

FIGURE 1. WINDOW-TYPE ROOM AIR CONDITIONER

* Commercial Engineering Division, Air Conditioning Department, General Electric Company, Bloomfield, New Jersey.

most independent of wind and it filters the air. Moreover, when a small percentage of fresh air is added to the room air passing through the air conditioner, odors that otherwise might become objectionable are diluted.

Room air conditioners have been built in sizes as small as one-quarter horsepower; however, it has been generally proved that one-half horsepower is the smallest practical size. A small, room air conditioner consumes only about 750 watts. This size will take care of most bedrooms and will do an acceptable job in small living rooms, providing the room and its windows are reasonably well shaded. Although three-quarter horsepower, one horsepower, and larger units will be built for larger rooms, there is a practical reason which limits their size. Larger rooms often require better air distribution than can be provided by one unit, and as a result better performance is obtained with two smaller units. Room air conditioners have performed admirably, and they constitute our best means of bringing summer air conditioning within reach of everyone. They are true air conditioners too, performing all of the functions of true summer air conditioning—cooling, dehumidifying, filtering, circulating, and ventilating.

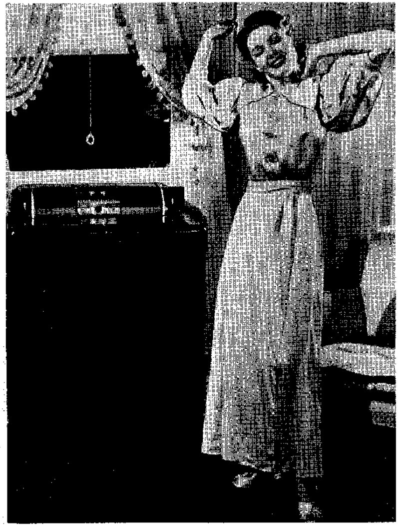

FIGURE 2. FLOOR-TYPE ROOM AIR CONDITIONER

The units built in the past have been excellent, but this does not mean that we can stand still. Our development obligations are clear: we must lower the price and reduce the size and weight in order to increase their portability and make them easier to install, and we must improve their appearance. Although these units will provide positive ventilation of clean air in the winter, many users do not feel a need for this benefit. Consequently, unless the units are particularly good looking and take up but little space, the user will prefer to store them for the winter. It behooves us, therefore, to make them light and easy to install. Fortunately, this goes hand in hand with improvement in appearance and reduction in size.

The alternative to the room air conditioner is the central plant air-conditioning system. In choosing a method of air conditioning, however, these two are not strictly alternatives, but rather complements, because the latter system is a step beyond the room air conditioner. Hence, when more than one or two rooms are to be air conditioned, the central plant system should be considered. The functions of this system are the same as the room air conditioner; namely, cooling, dehumidifying, filtering, circulating, and ventilating. Accomplishing this throughout the entire house brings to mind immediately the use of a duct system which, in turn, suggests the type of heating; i.e., forced warm air. Thus, the central plant summer air conditioner more or less demands the use of forced warm air heating, since, with the use of a duct system common to both, the two can be nicely coordinated into a year-round air-conditioning system.

A forced warm air heating system in its modern form heats, humidifies, filters, circulates, and when called upon can ventilate the air in a home. To complete the requirements of year-round air conditioning, it is necessary to add only cooling and dehumidifying. Therefore, if we have a forced warm air heating system, install an air-conditioning coil in the main duct trunk of that system, and connect a condensing unit to the coil, we have added all the functions required of a complete, year-round air-conditioning system, as in Figure 3. The condensing unit should be located so that noise and vibration will not be transmitted to the living quarters of the home, or the unit should be isolated by a suitable enclosure. In order to facilitate such an installation one manufacturer has combined the condensing unit and the coil into a single unit so that the installation work is reduced to setting the unit close to the furnace, arranging the ducts for air to pass through the cooling unit, insulating and making the usual electrical and plumbing connections; this unit is illustrated in Figure 4.

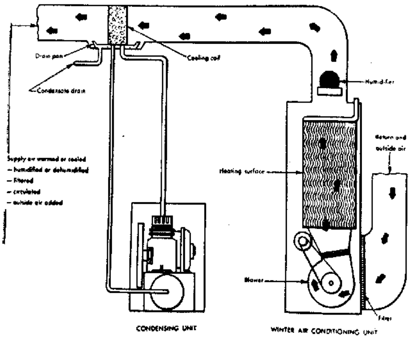

FIGURE 3. CENTRAL PLANT AIR CONDITIONER WARM AIR TYPE

While it is apparent that summer air conditioning and forced warm air heating are easily combined into a year-round air-conditioning system, the foregoing is not intended to preclude the use of steam and hot-water heating equipment. The air does not have to be heated directly as in a warm air furnace, it can just as well be heated indirectly by a boiler and a steam or hot-water coil. Generally, however, economics favors a warm air furnace, but the indirect system also has advantages. Figure 5 shows the indirect system using an air conditioner, boiler, and condensing unit; the steam coil in the air conditioner is supplied by the boiler and heats the air in winter. With this system, radiation is easily added where it is most important

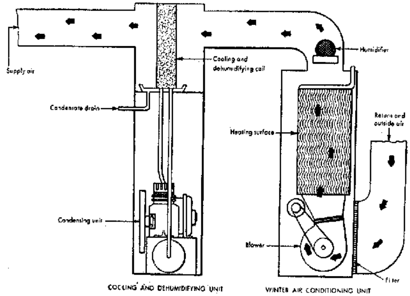

FIGURE 4. CENTRAL PLANT AIR CONDITIONER UNIT WARM AIR TYPE

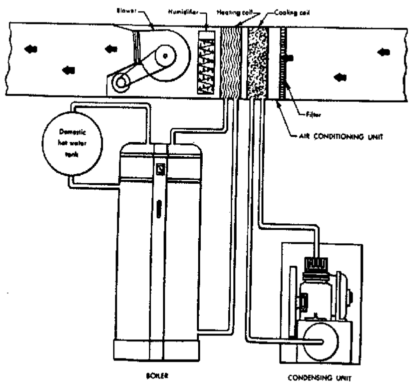

FIGURE 5. CENTRAL PLANT AIR CONDITIONER INDIRECT SYSTEM

as shown in Figure 6, in bathrooms, kitchen, garage, and, in some cases, the game room. Thus, the split-type system, which has received such favorable comment from home owners, is obtained. Another advantage of this system is that the boiler can provide year-round domestic hot water which is not easily obtained with a direct-fired, warm air system.

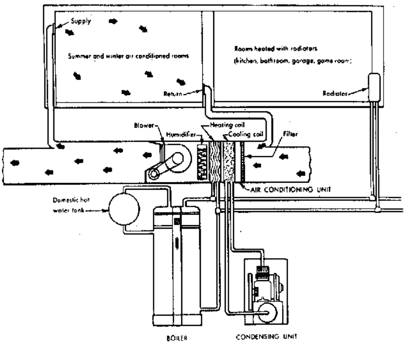

FIGURE 6. CENTRAL PLANT AIR CONDITIONER SPLIT SYSTEM

These central plant systems can be added to a heating system. This is an important point because usually the home builder or purchaser is stretching his pocketbook. In any event, it is often convenient to postpone, for a few years, the expense of year-round air conditioning. In such cases, the heating system should be designed by a competent air-conditioning engineer. There are important considerations such as duct sizes, outlet locations and insulation which are best taken care of when the heating is installed. This is not to say that air conditioning cannot be added easily to existing warm air heating systems, for it can be; however, it is better, and usually less expensive, to get started on the right foot.

For those who will plunge right in and install air conditioning in their new home we can add the system shown in Figure 7. In this case, a self-contained air conditioner can be used in conjunction with a boiler. This unit normally contains an air-conditioning coil, a condensing unit, a fan, and filters; a heating coil and a humidifier can be easily added. With this unit and the boiler all the requirements of air conditioning are met. This system will provide year-round domestic hot water and is the basis for a split

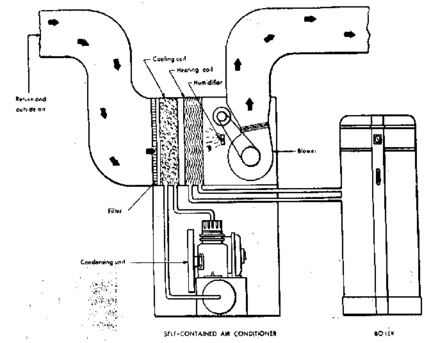

FIGURE 7. CENTRAL PLANT AIR CONDITIONER COMPLETE, INDIRECT TYPE

system if one is desired.

Doubtless, something about the size of equipment is in order. The size is generally expressed in tons of refrigeration or condensing unit horsepower. Usually with this type of refrigeration application, one ton of refrigeration can be obtained for each condensing unit motor horsepower. A large house will require a five horsepower condensing unit; however, a three horsepower unit has served and will, no doubt, continue to serve the large majority of air conditioned homes. As prices are lowered and the central plant air conditioning market expands, it is expected that two horsepower will be used extensively.

It is likely that the components of some or all of these systems will be combined into a factory-designed, and possibly packaged, year-round air conditioning units. This seems a logical step and it will aid in reducing the price to the home owner, which is of the utmost importance to all of us. It is virtually impossible to present information on prices because of the many variables involved. A reasonable estimate is that the cost of adding summer air conditioning will not exceed the cost of the heating system alone. We are hopeful that we can do much better.

Operating costs vary still more, depending on power and water costs, use of water-saving equipment, climatic conditions, house construction, etc. Generally, however, it will be substantially less than the cost of heating in colder climates.

Finally, a presentation such as this is not complete without some word about the two newcomers, the absorption system and the heat pump. Functionally, neither adds nor omits anything; they provide the same kind of air conditioning as the systems which have been described.

The absorption system is generally considered as a gas-fired unit; actually, however, it can be used with any fuel. Oil absorption systems have been built. In fact, kerosene operated domestic refrigerators have been used, and coal could and may be used. The choice of the absorption or the mechanical compression system is largely economic, dictated by the relative costs of fuel, electricity, and cost of water. Condenser cooling is a less difficult problem with the mechanical compression system. The absorption system, of course, has advantages in quieter operation and fewer moving parts.

The heat pump uses electricity for heating as well as cooling. It is, nevertheless, very efficient, as some 75 per cent of the heat required is taken from cold water or cold outside air. Since the heat pump requires considerably more development, it will probably not disturb the mass market for a number of years.

DISCUSSION

J. H. Kerrick presiding

R. J. GRACE[1]: I want to commend Mr. Marshall on the presentation of his paper. How will new home designs incorporating complete insulation and solar heating affect summer air conditioning?

G. K. MARSHALL: I think the tight home favors summer air conditioning. The more insulation the better. Thermopane is not too effective but it helps. The use of awnings and wide eaves that shade the windows in the summer, but will admit the sun's rays during the winter, are also helpful.

DISCUSSER FROM FLOOR: Are they a prime consideration in economics and original purchase?

G. K. MARSHALL: The more insulation the better, both winter and summer.

C. M. HUMPHREYS[2]: Throughout his presentation, Mr. Marshall was careful to use the terms *summer* air conditioning, *winter* air conditioning, and *year-round* air conditioning. It would be helpful if those interested only in winter air conditioning were as careful of their terminology.

There are a number of things which the architect can build into the home or recommend to the home owner which will improve summer comfort until that far-off day when all homes may have summer air conditioning. Insulation has already been mentioned, although we are not as sure of the type and amount required for summer as for winter conditions. The

[1] Analyst, Mineral Industries Experiment Station, The Pennsylvania State College.

[2] Senior Engineer, American Society of Heating and Ventilating Engineers, Research Laboratory, Cleveland 6, Ohio.

effects of the heat capacity of insulation on summer cooling requirements are not fully known.

Attic fans, which move large quantities of cool night air through a residence are quite effective in most parts of this country in reducing inside temperatures.

In some of the hot, dry regions, comparatively cheap evaporative cooling systems can be employed to advantage.

The heat gain of any structure can be materially reduced by the use of awnings over the windows. Shading by trees, ivy, etc., is also helpful.

Windows or louvered openings should always be provided to permit natural air motion through attic spaces. Where excessive heat gain occurs through flat roofs, a coat of aluminum paint will materially reduce the absorption of solar radiation.

I. J. FAIRCHILD[3]: I would like to ask Mr. Marshall if they have given consideration to the use of a radiant heating system with summer air conditioning.

G. K. MARSHALL: Yes, to some extent, but more work is in order on methods of combining summer air conditioning and radiant heating.

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[3] Chief, Division of Trade Standards, National Bureau of Standards, Washington, D. C.

Some Things We Have Learned About Housing Construction

By Howard Leland Smith*

In the past eleven and one-half years since the Federal Housing Administration was established, it has insured millions of mortgages and loans made by private lending institutions for the purpose of financing the construction of new houses, apartments, and the repair and alteration of existing ones. In this great volume of work, the dollar value of which runs into billions, it has been one of the principal duties of F.H.A. to see that the methods of construction used conformed to its established requirements. In this activity, the staff of F.H.A. has had and will continue to have the opportunity to observe housing construction on a national scale. Consequently, it is reasonable for you to assume that we of F.H.A. are in a position to tell you some things that have been learned about housing construction.

Before delving into detailed accounts about these things which have been learned, it is pertinent to describe a condition which was experienced in the early days of the Federal Housing Administration. It was not only expedient, but also necessary that Minimum Property Standards be established at the earliest possible moment so that a basis would be available on which to determine eligibility of properties offered as mortgage security. This was no easy task. Our technical staff worked day and night to develop a set of requirements which were believed to be reasonable and which, it was assumed, could be applied nationally. Soon after they were put into operation, it was evident that all was not well. At best it was an experiment, and what was learned by it has done more than any other one thing to convince the F. H. A. that the problems of housing are to a large degree local in character, and must be treated accordingly. The F.H.A. was soon to learn that requirements applicable to Maine were not suitable to cope with conditions peculiar to California. Consequently, what was first thought to be a comparatively simple solution of our Standards problem turned out to be one filled with complexities.

Later, as our activities increased, it was evident that there was a need for minimum construction requirements to be used as a basis for issuing commitments on new construction. As these requirements were developed, we became conscious of the problem of local building codes. In some states F.H.A. was confronted with county and state regulations governing construction. As a matter of principle, however, precedence was given to local codes wherever they exceeded our requirements for the same area. Unfortunately, some codes make excessive demands for construction work to the extent that many low income families are forced to find shelter outside city limits, where houses are less costly to erect. For instance, one western city forbids anything but masonry construction even in its residential area. A large city on the Mississippi River still clings to a code which requires a minimum thickness of twelve inches for masonry walls, regardless of height. These are typical of the many things learned that challenge our efforts to lower the cost of construction.

Of particular interest are some of the results of a survey made some time ago relative to code requirements as they apply to floor loadings for residential construction. Although 40 pounds has long been recognized as a suitable live load for this type of work, the survey revealed that codes varied anywhere from 20 to 100 pounds per square foot, with the largest of any one group using 60 pounds as their minimum. When one of the officials administering the code with the hundred pound requirement was asked, "Why the

* Principal Architectural Adviser, Underwriting Division, Federal Housing Administration, Washington, D. C.

excessive demand?" he replied, "To take care of loads caused by jitter-bugging." There is little doubt but what he was sincere in believing that by such means, a few skulls might be spared from fracture should a ceiling give way under the abnormally violent gyrations and concentrated impacts which are common to this style of dancing.

There are hundreds of codes throughout America, with no two alike. Considerable effort is being made to standardize them and some progress is being made. It is my personal opinion that codes will continue to vary from place to place, and that many of the variations are justified, especially when conditions of a local nature demand special controls. Moreover, it is my belief that much of the criticism directed at codes is not altogether fair, for codes are essential for the protection of life and health. Many a life has been needlessly sacrificed due to structural failures, lives which might have been spared had there been codes with proper enforcement.

Consider for a moment the problem which confronts the prefabricated home industry in its effort to obtain approval of products by local code authorities. The latter argue that it is impossible to determine the quality and character of the construction behind the surfaces of shop-made panels. The writer knows of one city where prefabricated houses are acceptable to the building commissioner, but, as a rule, the units receive a reject from the electrical and plumbing inspectors. Still, you cannot altogether blame the latter if they are conscientious public servants, for it is obvious that they will be unable to perform their duties properly without some type of X-ray equipment to see through the fabricated walls. Of course, most home manufacturers have to a large degree solved this particular problem by leaving off one side of the panel containing the plumbing work. There is also a move on by the industry to have the houses certified by the various code authorities before being shipped to the site. It is all very complicated and certainly a most discouraging problem for the prefabricator.

It is our F.H.A. policy not to require more in construction requirements than is necessary to assure structural soundness; however, there is one exception. In the City of New York, the code requires not less than eight inches of masonry around flue linings for chimneys. As much of the city extends over Long Island, it was the opinion of the technical members of our local office staff that this regulation be incorporated in F.H.A. requirements for all of Long Island since the character of construction in the area justified its need. Reluctantly, their request was heeded even though it was not necessary for the purpose of structural soundness, but purely as a means to compensate for the lack of good masonry work in the area. This experience makes one realize that there are times when one should be a little more considerate of local authorities when an occasional requirement in a code appears to be too demanding. Of course, there are those obvious cases caused by the action of selfish interests, for which there is no honest defense or legitimate excuse. So much for codes.

The Federal Housing Administration has always recognized the need for and the value in manufacturers' specifications; however, it has learned that unless they are followed, a structure can suffer materially. For example, some years ago a manufacturer of wall board sought F.H.A. acceptance of his material as a substitute for ordinary wood sheathing. Upon examination by laboratory tests it was found acceptable, subject to adequate nailing. To accommodate this requirement the manufacturer proceeded to have indentures made wherever a nail would be needed. After a few field inspections by our architectural inspectors, it was found that the average carpenter completely disregarded the nail location marks and drove the nails at random or wherever the spirit moved him. In this case the manufacturer's specification for the application of his material was completely disregarded. This situation caused considerable difficulty before a solution was found that would prove satisfactory to both the manufacturer and ourselves.

In 1935 F.H.A. was active in the initiation of the small house program. The industry accepted it as a challenge and came through with flying colors. As a result of this program, thousands of people were able to buy small, well planned and soundly constructed houses at prices which they could afford to pay. Unfortunately, in this effort our minimum standards were set too low with respect to closet and storage spaces. With the coming of the war and the further need for cutting down of floor areas, it was found that storage accommodations were already at a minimum and could not stand further cuts. Recent housing surveys indicate that this is a problem which needs serious attention. To meet this situation F.H.A. is now endeavoring to find a solution which will provide adequate storage space in the future home.

There are some design principles in frame construction which competent technical authorities have long recognized as essential to sound construction. After checking with our local offices relative to these principles, it was quite a surprise to find that in some areas they were the exception rather than the rule. One of these principles pertains to corner bracing. When resistance to the adoption of this requirement on the basis that it would cost too much was met, a study to determine how much the builder would actually pay was made. Much to our surprise, it averaged around $1 per corner and seldom ever exceeded $2.50. Today, it has become common practice; and surely, there will be fewer complaints from home owners relative to cracked walls, especially from those areas where high and continuing winds prevail.

Another feature in houses which needed attention was that of the absence of protective measures to withstand termite attacks. The incorporation of such measures is an inexpensive operation during construction and one which can save millions of dollars each year in the cost of structural repairs. One thing which was learned about termites is that they are fond of poor lumber and bad workmanship. It is my belief that termite control is now commonly accepted in most areas known to have termite infestation, although we still find that some builders are reluctant to provide the protective elements.

Now, let us consider a plan problem, namely, the basementless house. It is a problem which recent experiences have brought into clearer focus and from which, I believe, much has been learned. In our early efforts to cut housing costs F.H.A. suggested, and even went so far as to advise builders to eliminate basements, especially in those areas where they were and still are traditional. Although one hates to admit an error, it now appears that we were laboring under a false idea when we thought the basementless house was an economical measure. Sales resistance was the first reaction experienced by builders who had the courage to build a few such units. Regardless of how sound a structure may be or how well designed, if it does not find public acceptance, it is folly to continue to build it. The next thing learned about the basementless house was that its foundation walls and footings cost about the same as those for a basement house, especially when the footings extend down three and one-half feet or more below grade to resist frost. It was also found that extra and costly floor area had to be added to the basementless units to accommodate heating facilities, laundry equipment and storage space. Furthermore, it was evident that more expensive types of heating equipment would be necessary if located on or above grade. Cold floors in winter are another common complaint frequently received from those living in houses without basements.

There has been considerable effort to overcome some of these deficiencies by the use of concrete slabs at grade level. To a large degree, this is the solution to the cold floor problem, but it is not the answer to the others. It has been learned that a slab must not continue out under the exterior walls, but must be insulated at the inner face of the walls to prevent conduction of cold from the outer edge of the slab. A real drawback to the use of the slab is that it does not provide access to plumbing lines under the slab, or to piping which may be imbedded in it, such as is customary in panel heating. Considerable research and experimentation will be required before the slab idea can be generally adopted, except in those areas where climatic conditions make it not only logical but also desirable.

The Federal Housing Administration is fully conscious of all the research going on in heating, and from time to time new ideas are submitted to its heating engineers, who in turn spend much time in the field observing tests and determining the acceptability of the new equipment. Now and then a new system looks both practical and promising, but in most instances, it has not been sufficiently thought through. Some years ago one of the leading manufacturers in the heating industry produced a new system of house heating which had every right to be successful. It was so flexible in operation and simple to install that F. H.A. did not hesitate to accept it for a number of houses on which commitments had been made for mortgage insurance. One winter's operation, however, was sufficient to develop enough "bugs" to make the system useless. Fortunately for the owners, the builders, and ourselves, the manufacturer replaced the systems with standard equipment at his own expense.

During the past four years when the heating industry has been challenged to produce so much with so little, new ideas have come forth which hold promise for the future. How successful they will be, depends largely upon the ability of the engineers to weed out the weak spots which have developed under use. It might be added here that much of the trouble experienced during operation can be attributed to poor workmanship during installation and in some cases, careless firing. It is evident that there is always the primary need for simplicity in design and a "foolproofness" in operation. Please bear in mind that in our F.H.A. activities we are always thinking in relation to the needs of the small- or medium-sized house to shelter the great mass of low-income people. Exceptions to this rule come only in those instances where we are concerned with large rental housing projects, with central heating systems demanding experienced handling.

While on the subject of heating, it should be mentioned that it has also been learned that much damage to equipment results from trying to cut operating costs. For instance, the cutting off of fans to save electricity and failure to change air filters when necessary are both causes for overfiring. This often results in damage to the unit, cutting its useful life, and in some cases setting fire to the structure. False economies of this character in rental projects usually result in heavy turnover of occupancy with considerable loss in income from vacancies. Something has also been learned about the vital need for venting certain types of heating equipment such as that used in individual rooms, especially when gas is used. Likewise, the venting of enclosed spaces for heating equipment and the provision of a source of fresh air for combustion purposes are essential to efficient operation.

Although there may be other things which might be discussed about heating, some time should be spent on the subject of insulation. Insulation has cut materially into the heating industry, and its extensive use during the war emergency made available much critical material for other vital war uses. As an industry, it has grown by leaps and bounds, primarily because it has offered so much for so little money. However, insulation must be intelligently used and properly installed if adverse effects on other parts of the structure are to be avoided. We all know what happens when water vapor penetrates insulation material, how important it is to maintain a vapor barrier, and when and where the barrier should be located. It is all very simple to specify or show on shop drawings how it can be accomplished. But, and in this case it is a very large but, how can the destruction of these barriers be overcome when the plumber, electrician and other mechanics are not prevented from hacking them to pieces while installing their respective equipment?

One more comment on the subject of insulation is pertinent, something which has been learned about its use against heat, and not as insulation is usually thought of in its ability to resist cold penetration. Here again it is how the insulation material is used, and not by any means an inherent fault of the material. We have learned that when insulation is subjected to long spells of high temperatures, it will store up heat within itself to such a degree that its insulation value is impaired. To overcome this, the material must be opened to air circulation to permit its cooling off after the source of the heat is removed. This condition exists primarily in or under roof surfaces, and it has been suggested that attic fans be used to expedite the cooling off process. This, however, is not possible in insulated flat roof panels. Moreover, experience with flat roofs in northern areas has demonstrated the need for hung ceilings and vapor barriers, not so much as to prevent heat penetration in summer, but to prevent condensation in winter.

Now many of these things which have been mentioned are, perhaps, not news to you; nevertheless, I believe you should refresh your memory with these facts from time to time; there is always a tendency to overlook them, especially when one's mind is too centered in the development of a new idea. Seldom a week passes in Washington when we of F.H.A. are not called upon to analyze some new method of construction or examine a new piece of mechanical equipment. Some of the schemes presented are beyond description.

Ordinarily, one glance is sufficient to realize they are doomed to failure. However, it is our duty to examine each one carefully, point out inadequacies wherever they appear, and suggest remedies when the opportunity presents itself.

It may be of interest to you to know that the sponsor of any special method of construction who is desirous of obtaining a technical ruling from the F.H.A. is required to erect a full-size demonstration structure for our observation and study. Although this is usually an expensive operation for the sponsor, experience has taught us the need for it. In addition, we can determine possible public acceptance of the idea or design.

Vast sums of money are spent each year in housing research in an effort to provide good shelter at costs far below the usual price range. Accomplishments so far have been so limited that one wonders if it is worth all the human effort. Perhaps the real answer would be in a concerted attempt by the best minds in the industry similar to the effort put into the atomic bomb. Many of the new ideas in housing are not the product of technical minds, but of people who do not have a fundamental understanding of materials, how they react to the elements, and how they work when placed together. It is with a feeling of regret that I report that many members of my profession are so lacking in knowledge of the proper use of materials that they are easily led into the development of designs which, when carried out, prove unsatisfactory. It is all very easy to make a theoretical piece of wood conform to one's desires when in the act of indicating it on the drafting board, but what happens when it becomes a real piece of wood in a structure is an entirely different thing. What the drawing fails to show or to make allowances for, is the tendency of wood to swell, shrink, or warp. What is really needed in housing is some realistic thinking and not so much day-dreaming.

If you are like most people, I believe that you will want to know what F.H.A. has learned about housing design. By design, is meant the character of architecture, whether it be English, French, Spanish, Early American or just plain modern. As each of these styles were "modern" in its day, so it may be assumed that a design which is "modern" today may be considered an accepted style tomorrow. There is always the possibility, however, that it may turn out to be a fad. Heaven only knows, there have been plenty of them in the past. One of our greatest problems today in the Federal Housing Administration is to determine whether all of the various creations submitted today, as modern design, will eventually find public favor and be accepted tomorrow, as a style, or will be relegated to the category of fads. Houses, the designs of which fall into the latter group, present poor risks for mortgage insurance.

It has been my privilege to visit many houses of modern design especially in the South and Southwest. Some were exquisitely handled both as to materials and plan, while others were dramatic to the extent that livability and privacy were conspicuous by their absence. Modern design with its simplicity of line and masses does, however, require unusually fine workmanship as well as the best grades of material to be effective. Consequently, it is an expensive style to adopt and must, therefore, anticipate a limited market. It is the public reaction to these machines for living, as they are sometimes called, which gives us our cue to their acceptability for mortgage insuring purposes. Although the great majority of home buyers still prefer the older styles, I believe there is much that can be assimilated of the new that will benefit housing in the future. Perhaps the best that can be anticipated is a slow, evolutionary process. Certainly, a slow change would be more desirable to avoid possible adverse influence on the general economy.

In the past 50 years, a slow but, nevertheless, definite change has occurred in house planning. The impact of the automobile has tended to eliminate the front porch, move the kitchen to the front, and locate the principal living rooms to the rear. This is a logical trend; nevertheless, thousands of houses are still being designed in line with the thinking and the needs of the horse and buggy days. It all points up to one thing, and that is that the habits which man has adopted over the centuries will not be radically changed overnight. It is now apparent that the dream house planning drive to which the public was subjected during the war period is having little if any influence upon the prospective home buyer. Further evidence that the drive was not effective is that home builders sensitive to market demands have indicated their intention to continue pretty much the same character of styling as they were using before the war.

Before closing, there is one more thing which, purposely, has been left to the end, something which has been learned about housing and something which holds a number one priority. That is the need for intelligent planning. There is no substitute for it and there is no excuse for being without it. Of all the things that have been learned in our F.H.A. housing activities, it is the one thing we must strive to maintain at a high standard if the production of good housing is to continue in this postwar era just beginning. It has been proven beyond any question of doubt that poor planning is an item too expensive for the home owner to assume. Moreover, it is one of the principal causes for bringing blight to a community.

In the eleven and one-half years of F.H.A., the standard of planning has improved immeasurably, and in some places far beyond reasonable expectation. In the early days of F.H.A., I saw plans submitted to our offices in the form of pencil marks made by carpenters on a shingle, or just crudely drawn lines on an old brown paper bag. It was a tragic thing in those days to see such a low type of planning, if one could call it planning. If this were to happen today in those same offices, it would be considered a joke. Yes, we have made headway and there is no reason why we should not go forward to greater achievements in our planning activities.

Today, as never before in our history, America needs millions of well-planned houses, houses that are well constructed, well heated and well lighted. We at F.H.A. believe the industry will meet this demand. Our nation's war achievements are proof enough that there is no problem of production too great for American ingenuity to solve. Just how this housing problem will be met is still a question that baffles the minds of the most competent technical authorities. I, personally, hope that some of these things which have been learned about housing construction will be heeded by the industry so that in its future activities, it may take stock and benefit accordingly.

Commercial Standards—Their Functions in Heating and Housing

By I. J. Fairchild*

It is indeed a pleasure and a privilege to discuss commercial standards and their function in housing and heating. Some of the commercial standards already established in these fields have encountered difficult going during the war period because of limitations on raw materials, although in some instances, notably in the lumber field, the war period has accentuated and broadened the use of commercial standards.

STANDARDS VERSUS SPECIFICATIONS

Lest there be any misunderstanding, it may be well to differentiate between standards and specifications. In the past it has been customary to develop specifications for the quality of a product chiefly as a basis for contract buying. That is, purchasing agents for large railroads, public utilities, municipalities, and private companies ask for bids on the basis of a definite specification, let the contract to the lowest bidder, and test deliveries in accordance with the requirements of the specification as a safeguard against "chiseling." In too many instances, the manufacturer or supplier looks upon the transaction in a "catch-me-if-you-can" attitude, because in order to get the contract he has been more or less forced to cut as many corners as possible. Professional purchasing agents also have recognized the limitations of this method of buying and have come to place reliance for hidden quality *partly* upon specification requirements and tests, and *partly* upon the general reputation and standing of the seller. It frequently happens that any inferiority of materials purchased on specification is not discovered until after some of the delivery has been used or built into a structure. It is customary in many instances to accept goods that are inferior in some respects, provided an adjustment in price is made. Advance assurances of quality would largely eliminate these difficulties which are objectionable to all parties at interest.

When all the transactions in a given commodity are considered, it is obviously much more efficient to inspect and test the product for quality at the source, rather than to have this inspection and testing duplicated by or for a large number of customers after delivery. It is a common observation that the trends in production, distribution, and other phases of commerce are in the direction of methods which provide greater efficiency; perhaps, therefore, this may be cited as one of the reasons for the present and continuing trend toward testing at the source rather than after delivery.

A further reason for the latter trend is the conviction on the part of trade associations that, instead of each company struggling to snatch business away from competitors by questionable methods and, therefore, helping to demoralize and destroy the industry as a whole, it is better for all concerned to raise the quality of the product and to cooperate in improving consumer acceptance of, and reliance on, the product. As a consequence, the entire industry may elevate and expand its business to higher levels of dependability and stability.

Moreover, the trend today is definitely toward a voluntary emphasis on grade classifications, performance characteristics, specifications, and standards for the actual quality of the product as bases for market-

* Chief, Division of Trade Standards, National Bureau of Standards, Washington, D. C.

ing. This refers not only to sales to contract buyers, but also to all ordinary sales of a given commodity. The trend in this direction is such a natural development, such a normal thing to expect when *buying* that the deeper significance and the beneficial results obtained may be easily overlooked by industries not utilizing such methods in *selling* their products.

COMMERCIAL STANDARDS

For more than 23 years the Division of Trade Standards has been working quietly with industries asking its aid in implementing the trend mentioned above by establishing standards as a basis for marketing; *not,* however, to make their products uniform, nor to give up any design differences, nor to surrender any selling points, trade names, trade brands, nor any other individual advantages, but rather to enable these industries to find some common ground or platform on which they could stand together to improve public understanding and acceptance of the product, to provide fair competition, to broaden markets and to assume leadership in the preparation of reasonable specifications. Furthermore, this would minimize the need for testing on behalf of the purchaser, because the seller would be voluntarily accepting and declaring his responsibility for the proper sizing, rating, or other important characteristics, generally hidden, of his product.

The Division has established some 129 (10-19-45) voluntary commercial standards in cooperation with as many industries, and we have more active projects now in course of development than ever before.

EXAMPLES OF STANDARDS OUTSIDE OF HEATING AND HOUSING

Prior to 1934 the words "gold filled" indicated merely a *process* of manufacture, and *might* be applied to weights of karat gold coating over base metal of a weight ratio as low as 1 to 500. As a result of the establishment of a voluntary commercial standard for the Marking of Gold Filled and Rolled Gold Plate Articles, namely CS47-34, "gold filled" now signifies a quality not less than 1/20 10K. If you are wearing eye glasses with gold filled frames, it is likely that they are marked on the bridge and on both bows, first, with the manufacturers' trade mark, followed by "1/10 12K G. F.," which means that 1/10 of the metal in the article is 12K gold, and you may depend upon that mark.

The jewelry industry has had an excellent opportunity to compare results obtained through voluntary standards with those obtained through the establishment of a Federal Law; namely, The National Stamping Act of 1906. Mr. Byron L. Shinn, counsel for the Jewelers' Vigilance Committee for many years, has told me that he can recall no instance of a prosecution under the National Stamping Act, although annually he puts out a report of hundreds of "cases" of action taken on the basis of four commercial standards in the jewelry field, to correct abuses and misrepresentations.

Violations of the National Stamping Act are matters for criminal prosecution, whereas under the voluntary commercial standards, violations are generally matters of equity, most of which are corrected without resort to the courts; however, a fair percentage are handled through the Federal Trade Commission, local weights and measures bureaus, and better business bureaus. Some cases, of course, *do* get into the courts, particularly those cases involving borderline issues not covered by the existing standards.

Significantly, the jewelry industry keeps coming back for more voluntary commercial standards. The last one, Marking of Jewelry and Novelties of Silver, Commercial Standard CS118-44, was promulgated May 15, 1944; and the Division is working with that industry now on a sixth standard to control the quality of gold electroplate, as well as on the revision of the Marking of Gold and Silver Combinations, CS51-35. The underlying objective of all of these voluntary standards is to improve, first, the quality of the goods, and second, to obtain public recognition and acceptance of the standards.

STANDARDS IN HEATING AND HOUSING CATEGORIES

The Division of Trade Standards has seven commercial standards in the heating field, mostly for heating equipment, with which you are no doubt familiar.

Domestic Burners for Pennsylvania Anthracite, CS48-40.

Automatic Mechanical Draft Oil Burners, CS75-42.

Gas Floor Furnaces, Gravity Circulating Type, CS99-42.

Flue-connected Oil Burning Space Heaters, Equipped with Vaporizing Pot Type Burners, CS101-43.

Warm Air Furnaces, Equipped with Vaporizing Pot Type Oil Burners, CS (E)104-43.

Solid-Fuel-Burning Forced Air Furnaces, CS109-44.

Oil Burning Floor Furnaces Equipped with Vaporizing Pot Type Burners, CS113-44.

In the housing category, including the elements of construction, there are no less than 18 commercial standards.

Staple Vitreous China Plumbing Fixtures, CS20-42.

Builders' Hardware, CS22-40.

Aromatic Red Cedar Closet Lining, CS26-30.

Wood Shingles, CS31-38.

Douglas Fir Plywood, CS45-45.

Wood-Slat Venetian Blinds, CS61-37.

Old Growth Douglas Fir Standard Stock Doors, CS73-45.

Solid Hardwood Wall Paneling, CS74-39.

Hardwood Interior Trim and Molding, CS76-39.

Sanitary Cast-Iron Enameled Ware, CS77-40.

Hardwood Stair Treads and Risers, CS89-40.

Factory-Fitted Douglas Fir Entrance Doors, CS91-41.

Earthenware (Vitreous-Glazed) Plumbing Fixtures, CS111-43.

Homogeneous Fiber Wallboard, CS112-43.

Porcelain-Enameled Tanks, CS115-44.

Standard Stock Ponderosa Pine Doors, CS120-44.

Prefabricated Homes, CS125-45.

Insect Wire Screening, CS129-45.

IMPORTANCE OF STANDARD TESTS

It will be noted that among the 25 commercial standards for heating and housing equipment, only two cover heating equipment using solid fuel. I believe that one of the reasons for this relatively small number is the lack of standard test methods and standard test fuels. Laboratories having experience in the testing of solid fuel burning equipment are in general agreement that it is difficult to compromise on simple standard test methods for solid fuel burning equipment so as to obtain comparable results. To complicate the situation there are differences due to variations in barometric pressures, and varying winds, differences in burning rates, kind and frequency of attention, type and characteristics of the fuel, drafts, amount of ashes retained on grate, and end-points for the test.

Test fuels, particularly bituminous fuels, add even further complications, although it is my understanding that some serious work is under way at Battelle Memorial Institute to see whether it may not be possible to select a single, standard bituminous test fuel for conducting laboratory tests. Possibly, factors will have to be applied to determine resulting ratings when other fuels are to be used in the actual operation of the heating equipment in service.

It is my personal feeling that, with all of these variables in the picture, it would seem reasonable to suppose that if test methods and fuels were standardized to the point of giving a reproducibility of final ratings within 5 per cent, a beginning worthy of the establishment of a standard shall have been made; and there is hope and promise that in due time, as the testing technique is improved and refined, the reproducibility should be better.

In any event it is obvious that unless a definite understanding can be achieved as to standard methods of test, and a standard test fuel which will provide reasonable reproducibility of results, we cannot hope to obtain agreement on a standard that may serve as a basis for overall performance requirements and ratings. Although some details of a standard test may seem too highly academic and fussy to many in industry, it is only by these means that conflicting and false claims can be eliminated from published ratings of heating equipment. In other words, the importance of standard test fuels and test methods cannot be too highly emphasized.

IDENTIFICATION OR LABELING

The growing complexity of our civilization, the trend toward greater specialization in the production of items in daily use and the introduction of synthetics, new finishes, and other innovations has led to strong and articulate demands on the part of consumers for informative and preferably guarantee labels. Nearly every high school and college conducts classes of students, as well as of interested householders, which are designed to educate the consumer on criteria for judging the myriads of items on the market. These classes generally gravitate to a study of standards now available for meats, dairy products, fresh and canned fruits and vegetables, household appliances, textiles, and other manufactured products, and especially, means of identification, or guarantee labels, which warrant that the item conforms to some nationally recognized standard.

Just prior to the war, there was a notable increase in the number of consumer organizations, such as county councils, clubs, institutes, leagues, and committees, generally with a two-fold objective; namely, educating the consuming public, and making its desires felt. Collectively, these efforts have resulted in definite and articulate pressure for informative labels, serviceability facts, grade marking, and other assurances of quality. Proof of this demand is found in the cash-register experience of retailers and mass distributors, through whose records the fact has come to be accepted that an immediate and sustained increase in business follows informative labeling, quality grading, certification as to quality, and like steps on the part of the seller. The recognized need for wise selection is doubtless also partly responsible for the rapidly expanding number of buyers seeking authentic information. The dependence that women are putting on labels is not likely to be forgotten in a more plentiful market. They are now learning, and will remember, that the merits of labeled goods apply both in wartime and in peace. Moreover, in recent years the Federal Trade Commission has taken up the cudgels in behalf of the consumer, in addition to its previous chief concern over unfair methods of competition.

In response to these trends, and demands for truth in merchandising and for informative and guarantee labels, there has come a tremendous increase in grade marking, warranties, guarantee labels and other legally-binding means of identification. In fact, the extent of such labeling or legally-binding identification will actually astound anyone who takes the trouble to investigate fields other than his own, such as foods, lumber, fuel oils, oil burners, plumbing fixtures, fabrics and jewelry.

ENFORCEMENT

In considering the question, "How are commercial standards enforced?" one must not overlook the fact that they are essentially voluntary in nature. No manufacturer or seller is compelled to produce his equipment according to a commercial standard. Neither is he compelled to identify it nor guarantee it as complying with a standard even though it does actually comply. On the other hand, when a majority of an entire industry reach an accord on a given standard as a satisfactory basis between sellers and buyers as to minimum requirements and basic ratings, and it becomes good business to make a voluntary declaration in the form of an identification symbol or label based upon a nationally recognized commercial standard promulgated by the Federal Government, and when this is demonstrated by the actual application of such identification or label to the finished product, the industry makes it possible for distributors and users to distinguish between items which are made up to a standard and those which are sold down to a price.

When a seller has made a public declaration either through a catalogue, sales literature, identification or labels on the product that it complies with such a standard, he thereby voluntarily assumes responsibility to the purchaser in a legally binding way, because such a declaration becomes a legal part of the sales contract and is enforcible as such. In the event of any misrepresentation, correction can be obtained through the Federal Trade Commission, local better business bureaus, local bureaus of weights and measures and other channels when the amount of the sale in dollars does not warrant taking the matter to court. The Division has learned through the years that manufacturers and distributors are watching one another for misstatements in such respects, and direct false claims are comparatively rare. Difficulties do arise on borderline questions which, in due course, result in adjustments in the requirements of the standard, so that the areas of misunderstanding gradually disappear.

FUNCTION AND PURPOSE OF COMMERCIAL STANDARDS

I hope that it has been made clear from what has preceded that the functions and purposes of commercial standards are not to make the product uniform, nor to give up design differences, but rather to serve as a platform which will stimulate competition, individuality in design, improvements in performance, and the assumption of greater responsibility for the significance of trade brands. Furthermore, these standards serve to make competition clean and fair, to bring about a better understanding between seller and buyer, to facilitate sales, to improve public confidence in the product, to broaden the market, to aid materially in reaching higher standards of living, and to strengthen our entire economy.

DISCUSSION

E. R. Hintz presiding

H. N. OSTBORG[1]: Is there any place, other than Battelle Memorial Institute, where a calorimeter room set-up is available for direct evaluation of bituminous coal-burning appliances, particularly hand-fired equipment?

I. J. FAIRCHILD: I am not a laboratory man. I think there are other places that have calorimeters, but perhaps not the complete equipment.

H. N. OSTBORG: A calorimeter room set-up is quite expensive and out of the means of many manufacturers and producers of coal-burning equipment. Because of this, is there a possibility of deriving a conversion formula or factor for approximating the efficiency and output values for bituminous coal based on tests with anthracite? Couldn't a calculated performance factor be developed which would be dependent upon the volatile matter content of the bituminous coal used and upon the smoke emitted, the latter determined by some accepted means of smoke measurement?

I. J. FAIRCHILD: My work is bringing about compromises between producers, distributors, and testing laboratories. I can tell you that we have tried to set up standards for two or three types of bituminous coal-burning equipment on the basis of using anthracite as test fuel; by and large, these standards are not accepted. The manufacturer likes to test his equipment with fuel to be used by the customer. I have been in conversation with Dr. Rose of Bituminous Coal Research, trying to see if we can't find one of the bituminous fuels which could be used in laboratory testing. Then, by applying certain factors based on known differences between the characteristics of this fuel and other fuels in the field, the factors could be applied when the equipment is going into certain areas.

H. N. OSTBORG: Wouldn't that depend considerably upon testing the equipment used for testing also?

I. J. FAIRCHILD: There aren't too many variables in the testing equipment.

W. D. LEINBACH[2]: Perhaps this is an embarrassing question to the speaker, but I would like his opinion on independent organizations, such as Consumers' Research, which are attempting to educate the public.

I. J. FAIRCHILD: I think their ability to get paid for what they are doing indicates the strong demand on the part of the consumers for some assurances. Civilization is becoming so specialized, not only in the professions, but also in manufacturing and distributing that the consumer has no way of judging; he can't tell whether a house is going to stand up or whether the furnace is going to keep on working. He needs some assurances, and his willingness to pay for

[1] Testing Engineer, Merchandise Testing and Development Laboratory, Sears, Roebuck and Company, Chicago 7, Ill.

[2] President, Milton Machine Works, Milton, Pennsylvania.

such services indicates the strength of the demand.

K. C. RICHMOND[3]: Have you had many consumer inquiries about heating equipment or fuels that go into new homes?

I. J. FAIRCHILD: They are coming in continuously.

J. H. KERRICK[4]: How far can the Bureau of Standards go toward seeing that the information they develop is put to practical use? I mean, if it is determined that certain standards should be met, are there any provisions in your regulations that will take care of the fellow who steps overboard and delivers something unsatisfactory?

I. J. FAIRCHILD: We have no authority to enter new fields or to punish anyone making false statements or claims. But, I have indicated how these are checked normally—as competitors the manufacturers are watching one another, so are the distributors. The Better Business Bureaus are watching carefully. Anyone hurt can go to the Federal Trade Commission. If the dollar value is high enough they can go to court. Those things are checked normally through other channels, they are not included in our job.

J. H. KERRICK: The solid fuel industry is making an effort to get the so-called small producer to build up standards to conform to the average product. The point was brought out yesterday about inferior products. These inferior products may be caused by factors far away from the producers' operations, but they do have a very distinct bearing on the attitude of the public toward the product. I am wondering if the Bureau of Standards program contemplated regulations that would give any industry the backing they need, to see that these standards are lived up to?

I. J. FAIRCHILD: We think that once you had regulations, you wouldn't like them. Identifications or labels, voluntarily applied on an industry basis in opposition to a company basis, will enable the purchaser and distributor to distinguish between good and bad products.

J. H. KERRICK: My particular company identifies its anthracite. When we have service complaints we can quickly determine whether or not it is our product. There are other companies who do the same thing, but that does not overcome the practice of the bootlegger who goes out and distributes coal as high grade. As a result, the customer becomes dissatisfied—he becomes dissatisfied with anthracite.

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[3] Editor, *Coal-Heat Magazine*, Chicago, Illinois.

[4] Fuel Engineer, The Philadelphia and Reading Coal and Iron Co., Philadelphia, Pa.

The "Comfort Seal" Plan—An Insurance Policy for the Coal Industry

By T. S. Spicer*

THE HOME is one of the most common and unique things in the modern world. It comprises some 30,000 items[1] and averages about 150 tons in weight. Yet, it differs from the automobile, radio, washing machine, etc., in that it is not assembled or prefabricated at the factory. The fabrication and arrangement of the numerous parts that go to make up the home is left largely to the judgment of the architect and builder. Consequently, because of differences of opinion, lack of information and experience, competitive construction, and other factors that face the men who control the fate of the home, many mistakes occur. Frequently, these mistakes are far-reaching in effect, and not only deny the home owner the satisfaction to which he is entitled but they also affect other industries. This article is concerned with the relationship between the design of the home and the domestic coal market.

DOMESTIC COAL MARKET

About 80 per cent of anthracite and 20 per cent of bituminous coal production is required to keep the people of this country warm. Moreover, aside from wood, about 75 per cent of the heat for keeping the people warm[3] comes from coal. Hence, it can be seen that, although combustion engineers often visualize the domestic market as a 5 or 10 ton per year per customer proposition, it really represents a sizeable market and is worthy of the serious attention of the industry.

* Assistant Professor of Fuel Technology, The Pennsylvania State College.

HOME BUILDING BOOM—AN OPPORTUNITY FOR THE INDUSTRY

A tremendous home building boom is now under way in this country. The National Housing Agency estimates that 15,000,000 homes will be built during the next decade. Whether this prediction comes true or not, depends on many factors such as cost of labor, cost of material, availability of labor and material, and a continued consumer demand. It is obvious that an acute housing shortage exists and the country requires millions of new homes. This situation affords a wonderful opportunity for the coal industry to establish its future domestic market at the time these homes are built.

In the past, many mistakes in design and construction have been made in building our homes and as a result, the heating plant has often been crippled. As the life of an average home is several generations, it can be seen that such mistakes must be endured for a long while. Besides, these mistakes are more difficult to rectify in the home than they are in industrial plants. And such mistakes that cause coal to be burned under adverse conditions always reflect on the product and hurt the market.

HEART OF THE HOME

Johnstone, et al., in their recent book, *Building or Buying a House*[2], state, "Building or buying a home represents one of the largest financial transactions of a life-time for the average family and it is usually the happy conclusion of many eager years of planning and conscientious saving." This event is to the individual, indeed, one of life's milestones. The design and erection of each of these homes presents many weighty problems. Keeping warm is one of the foremost things to be considered in planning a home. From the beginning of history, keeping warm(3) has always been a serious business of the human race. It is not strange then that the heating system is often referred to as the heart of the home. Cost analysis of a home by Johnstone, et al. and William B. Dixon[1] indicates that the complete heating system may represent as little as 5 to 12 per cent of the total investment. Yet, it is almost continually contributing to the health, happiness, and comfort of the occupants of the home. Economizing on the heating system is pure nonsense, and this practice must cease if the home owner is to enjoy his home to the fullest extent. The safety slogan, "One thought before an accident is worth more than a million afterward" is an axiom which may well be applied to heating systems and housing construction. Although hindsight is more accurate than foresight, unfortunately it cannot always rectify mistakes.

BALANCED DESIGN

A great deal of constructive work is under way in the interest of upgrading domestic heating standards with coal as a fuel. The Anthracite Institute Laboratories, Bituminous Coal Research, Inc., the American Society of Heating and Ventilating Engineers Laboratory, the Division of Trade Standards of the National Bureau of Standards, the Stoker Manufacturers' Association, the American Boiler Association, and many others are engaged in this broad program. It now appears that some scheme to coordinate these gains into a complete set of standards is needed.

Possibly an illustration will explain more clearly what is meant by balanced design. For example, if a modern house is equipped with a boiler and stoker manufactured to the best standards, yet the chimney is too small for the heating load, the over-all heating system cannot function satisfactorily. Or, if the over-all system is just about perfect, yet the general design of the house is such that the coal must be delivered in an awkward manner and the ashes carried out through the living room, then again ultimate satisfaction is denied the home owner.

COMFORT SEAL PLAN

Most home owners are not qualified to appraise the heating system which embraces numerous components that must dovetail to give satisfaction. Nor, is there any convenient place where they can go for this advice. The architect and the builder, too, must be offered help in the design and construction of houses that use coal. The coal industry cannot allow this information to be acquired in an indiscriminate manner, but must sponsor a united program to render such a service. For sealed in the design and construction of these millions of new homes is the fate of the coal industries' future domestic market.

In view of the need that exists for the guidance of architects, builders, and home owners, a plan(4) is therefore proposed for guaranteeing high domestic coal-using standards. Briefly, this scheme involves two things: the first is to establish over-all standards, and the second is to put these standards into practice.

The minimum standards for new homes should cover the following components:

1. The general heating system:
   warm air—gravity—forced
   hot water—gravity—forced
   steam—vapor—split system
2. The furnace or boiler.
3. Stoker.
4. Controls.
5. Chimney.
6. Coal storage.
7. Service water.
8. House design with respect to ease of coal delivery and ease of ash removal.
9. Lay-out of furnace room with insulation against dust and sound.
10. General insulation and construction of house.
11. Air conditioning.
12. Proper installations.

This plan will require a national organization consisting of a director and board of governors. Under

[1] Director, National Association of Home Builders of the United States.

their supervision a testing laboratory, bureau of standards, service bureau, field inspectors, and possibly other departments would operate. The plan would function somewhat as follows: the service bureau would provide information for architects, contractors, and home owners. The blueprints of a home would be submitted to this bureau for criticism before the house is built. Upon approval, construction work would then follow, and after the house had been completed, a field inspector would check the house to see that the specifications had been met. Then upon acceptance of the job, a "comfort seal" certificate could be granted to the contractor which in turn would be passed on to the buyer. This certificate would tell the buyer that insofar as the heating system is concerned, he can expect satisfaction from it. Regional offices would be required throughout the coal using area in accordance with the concentration of coal-fired homes. From a study of the trend of the coal utilization standards, it appears as though the coal industry is on the verge of such a step right now. Standardization is underway everywhere, and all that seems necessary is a coal-industry sponsored program to accelerate a more widespread adoption and use of the existing approved specifications.

At one time it was believed that a small subsidy or fee would be necessary to induce the architect and builders to cooperate. This would be paid them for their time spent checking the bureau of standards. But after discussing this plan with contractors and architects, it is now believed unnecessary to subsidize, because they are more than willing to cooperate under such a scheme.

The "comfort seal" plan is not suggested as a compulsory one, but rather as an optional program. The plan should not mean further regimentation of the industry, but instead should stimulate free enterprise. If the public is fully informed about this idea, it is believed that it will demand a "comfort seal" certificate when buying or possibly even renting a home.

A CHALLENGE TO THE INDUSTRY

Please note that this proposal is not being presented as a crystallized plan, but rather as an idea which may help the coal and allied industries as well as the public. Much study and consideration are required by those of the industry it will affect. It is a gigantic undertaking and represents a multi-billion dollar industry. Probably the most difficult thing about this plan is how to set it into motion. It appears that the first step in the organization of such a plan is to set up information or service bureaus for the convenience of the users of coal. The responsibility of organization lies with the coal industry. This is a challenge to the coal industry to protect its domestic users, and by so doing, to insure its domestic market.

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DISCUSSION

E. R. Hintz presiding

R. S. DURBIN[1]: In view of the fact that Mr. Spicer has suggested or mentioned that every community has in its gas company a central office to go to for advice, this should apply in other fields, such as the Pennsylvania Retail Coal Merchants' Association, through its Secretary, Mr. Hintz.

C. L. EBBERT[2]: Some years ago the Red Seal Wiring plan was set up and was quite effective in trying to establish suitable standards for the wiring of homes. The building industry is one of the most disorganized major industries in the country, and I think anything dealing with a home must be an over-all plan. If we create perfection in one branch and have imperfection in another phase of housing, the desired result will not be accomplished. Yet, from the standpoint of the building industry, we have something to sell the home owner, and we should be the home owner's chief protection. I believe that the plan Mr. Spicer hinted upon is really a step in the proper direction.

A. W. GAUGER[3]: This is really a very constructive suggestion by Mr. Spicer. At the present time when building a new home, the owner has no assurance that his heating plant will function correctly. Burning of fuels is one thing; getting that heat into far corners of the house and distributing it properly is another. There is no way for the average home builder to tell whether these are in balance until he has a cold winter. Then he soon discovers that, even with the best of construction, one room is inadequately heated in cold weather. Or, he finds that certain rooms are over-heated and others improperly ventilated.

At the present time, the only way I know of for a person to assure himself of proper balance is to have a contract that guarantees a certain temperature condition throughout the house and that contract must be with a responsible heating contractor. Even then the owner should retain a balance on the contract figure until he has gone through a heating season to see if the contract is met.

The American Gas Association some 20 or more years ago established a laboratory in Cleveland. This laboratory was established largely for the purpose of testing gas appliances. I don't believe there is a gas appliance on the market today that has not been tested and certified by the American Gas Association.

I hope the members of this conference will give this suggestion considerable thought, because I think it is well worthwhile.

E. R. HINTZ: What do the anthracite people think along the lines of the procedure mentioned?

C. C. TYRRELL[4]: I think that anybody recognizes that the design of the heating system is more important than the fuel. Perhaps I am sticking out my neck, but that is my opinion at least for performance; if you have a satisfactory design, your fuel is usually satisfactory. I have heard men in our organization say that when they go into a home where there is a problem the first thing that is blamed is the fuel. The experience has been that probably 75-80 per cent of the time the fuel is not at all to blame; something inherent in the system is to blame. I think in our organization we have the fundamental necessities for operating such a plan.

D. R. MITCHELL[5]: I wish to point out that the oil industry tried somewhat the same thing. Those of you from the Middle West recall that when the natural gas lines came up through there, they had a central organization. Of course a lot of people used gas-heat. When a representative called on a prospective customer, the first thing he told them to do was to insulate; and certainly, they always had to fix up chimneys. In many instances the prospect was required to put on storm windows. They were thinking about over-all comfort when they put in the gas burner. Often home owners spent more in fixing up their houses than they did on their actual heating system. I know of cases where the gas company actually refused to put in burners until necessary repairs were made.

P. L. GROSS[6]: It seems to me that we are attacking the problem from the wrong angle. If

1 Salesman, J. M. Brunner & Co., Philadelphia, Pa.

2 Executive Secretary, Contractors and Builders Exchange, Reading, Pa.

3 Director, Mineral Industries Experiment Station, The Pennsylvania State College.

4 Senior Mechanical Engineer, The Anthracite Industries, Inc., Primos, Pa.

5 Head, Department of Mineral Engineering, The Pennsylvania State College.

6 Coal-O-Matic Stoker Co., Trucksville, Pa.

we are interested in new homes and what is going into the new homes, I think very definitely the architects need a little education. The gas and oil industries I think are doing a pretty good job of trying to educate the architects and they are doing it. At any rate, they are selling architects.

I was in an architect's office some time ago near New York. He was sold on competitive fuels. He had received a great amount of literature, sales material, etc., on competitive fuels, but not very much on coal.

Now if we get faulty systems in houses, it is all right for the home owner to put up with it; it is all right to say the heating man did a bad job. But, if the layman puts the money and design of home in the hands of an architect, it seems to me the responsibility very definitely should be on the architect. If these architects are willing to learn as Professor Spicer pointed out, I think we should do something, whether it is along the plan of Professor Spicer, which seems to be logical, or not. The architects are going to design more and more homes. Home owners are interested in getting comfort when they put money in a new home. It seems to me that we should probably work a little closer with architects.

C. M. HUMPHREYS[7]: I would like to make a comment which is not new to the conference, but is, rather, a restatement of the remarks of an earlier speaker.

Many of the troubles encountered in the average domestic heating system today are definitely the result of improper design. A very small percentage of the heating systems in homes costing $10,000 or less is designed by heating engineers. Many architects are quite content to specify that a house shall be heated to 70°F., and leave the design of the system up to the plumbing or roofing contractor who happens to be the low bidder. The coal industry can make a real contribution toward the improvement of residence heating by encouraging architects and builders to secure the services of competent heating engineers.

C. L. EBBERT: It seems that the volume of new housing will be in our small housing field. We can have a heating unit that may be absolutely perfect, that will be put into homes as a selling point, but if the home is possessed of any number of other faults—faults in construction that will cause heat loss—you are still not going to accomplish the desired results; and you are probably going to have heaped upon the stoker manufacturer, at least the heater man, a lot of fault that he is not responsible for, that lies somewhere else—probably in the construction of the house.

L. W. HOUSEHOLDER[8]: One thing I would like to point out. We distribute household appliances. Every day our dealers are sending in pictures of advertisements they have cut out of a magazine of model kitchens, laundries, etc. These are what they want in their house. What will it cost and how can it be put in? I imagine you home builders and heating fellows are going to run into the same thing. You are going to have hundreds of people building homes, putting in heating systems. We insist in our layout of new kitchens, laundries, etc., that the original plan be submitted to us by our dealer to make absolutely sure that what is going to be installed will work and do so satisfactorily.

K. C. RICHMOND[9]: What appeals to me about Mr. Spicer's plan is that it basically integrates the available information, standards and agencies to insure the prospective home builder or buyer a fairly decent standard of comfort, winter and summer.

Fortunately, due to research, the furnace manufacturers are making available standards, educational material, to insure the proper application and installation of warm air heating systems. Boiler manufacturers are doing the same sort of thing. Proper standards of design and performance of heating plants are available, but proper standards of installation are just as important. We have some of these standards, but they are not being used any too generally.

By taking advantage of tested, known standards of building and heating, the "Comfort Seal" could revolutionize our present standards of residential heating.

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7 Senior Engineer, American Society of Heating and Ventilating Engineers Research Laboratory, Cleveland, Ohio.

8 President, Whiteman and Company, Inc., Indiana, Pa.

9 Editor, *Coal-Heat Magazine*, Chicago, Ill.

Merchandising the Packaged Home

By Herbert F. Lotz*

THE GREATEST inherent weakness of the Home Building Industry is the merchandising and distribution of its products and service. Here the Home Building Industry has a great opportunity. There are more than 30,000 individual items for a home which are sold by the Home Building Industry and almost as many organizations selling them. There are 65 types of manufacturers of home building products. Moreover, some of these individual types of manufacturers run into thousands of individual manufacturing units competing in each type. Just to name one competing type of manufacturer, for example, there are over 20,000 saw mills producing lumber products.

There are 17 types of wholesalers, and 21 types of retail outlets for the Home Building Industry. There are 37 types of service organizations that are concerned with home building products. In addition, there are 33 types of retail salesmen who are concerned with influencing the consumer patronage in the field of home building products. Before the war, there were more than 165,000 builders of small homes, 20,000 of whom built more than 4 and less than 10 houses per year.

It is virtually true that nowhere in America can the American family buy a new home from a single individual or firm with financial responsibility to back the quality, and a service organization to take care of anything that might go wrong. Responsibility will be the biggest word in tomorrow's building industry market. No longer will the building industry be able to dodge the consumer who demands responsibility on the part of the man from whom he buys a home, responsibility equivalent to that which he gets when he buys an automobile. As an industry, we can no longer hide behind the skirts of the carpenter-contractor in the matter of responsibility, and pass on to him the full responsibility for both the materials and the skill with which they are put together.

There are several factors concerned with responsibility in the construction of a single new home; namely, the manufacturer who supplies the materials and equipment, the realtor who provides the lot, the architect who designs the house, the contractors and subcontractors who do the work, and the agency which does the financing. But the consumer cannot go to a score of places for responsibility, he wants a responsibility headquarters. This is one of the Home Building Industry's greatest opportunities. The Home Building Industry through the retail lumber and building materials dealer, the prefabricator, and other similar groups can and should offer a complete package, with full responsibility for quality and service. By so doing the consumer can deal simply and directly, and can eliminate the whole complex, inefficient, out-of-date, and highly costly method of distribution of the Home Building Industry.

The breakdown of the cost of the typical small home costing 5000 dollars including land, using prewar prices for labor and materials, is about as follows:

Land and Land Improvements	$ 600.00
Materials Cost to Distributor	1,050.00
Labor Cost at Job Site	1,400.00
Cost of Distributing and/or Delivering this Labor and Material to the Consumer in the form of a home, including distribution cost, costs of transportation, profits on materials, and contractor's overhead and profit	1,950.00

The home is the common denominator of nearly all

* Dealer Relations Division, Johns-Manville Sales Corp., New York, N. Y.

industry; it is the market for more than 65 per cent of all peacetime manufacturers in America; yet the Home Building Industry has never sold homes. In most instances, the Home Building Industry has sold lumber, shingles, roofing, insulation, composition boards, hardware, paint, etc. Furthermore, this industry has, apparently, never realized the importance to itself or to the national economy of selling the desirability of homes, as suggested by the results of a study, begun many months ago by the Curtis Publishing Co., on the effect of consumer "Designs For Living" upon the postwar economy. For, as the investigation progressed, it became increasingly clear that American families were genuinely interested in raising their standards of living through the medium of home ownership and home improvements; i.e., better housing. It also became evident that housing, with all its ramifications, could be a vital stimulant to sustained postwar prosperity and employment. Housing probably exerts a greater influence on our over-all economy than any other single industry, because it cuts across so many different fields of business activity. Thus, the market possibilities of the housing industry and its employment potentials have become matters of widespread interest and concern.

The first part of the Curtis Publishing Co. survey questionnaire on plans for home ownership showed that of all families interviewed, 34.3 per cent expect to build or buy a home to live in, 58.5 per cent do not plan to acquire a home and 7.2 per cent are uncertain what they will do. The building industry and others are frequently puzzled by the unwillingness of many families to undertake the responsibilities of home ownership. Some explanation of this attitude is given by those renters who say they do not expect to build or purchase a house to live in. Of the 58.5 per cent who do not plan to acquire a home, 31.4 per cent feel they cannot afford home ownership or that it is cheaper to rent, 14.1 per cent definitely prefer to rent, 11.9 per cent consider themselves too old, 8.8 per cent feel their location in any one place is too uncertain, 6.6 per cent say they already own a house and will return to it later, 4.8 per cent prefer apartments, 1.4 per cent expect to inherit a home, and 23.4 per cent gave miscellaneous other reasons.

The fact that the most pronounced resistance to home ownership was found to be its cost is quite interesting when contrasted with the attitude of prospective home owners toward the long-range cost of shelter. Of the 34.3 per cent who expect to build or buy a home to live in, 51 per cent feel that the cost of shelter will be less if they own a house than if they rent, 30.9 per cent think there will be no appreciable difference in the cost, 15.3 per cent believe home ownership will be more expensive than renting, and 2.8 per cent do not know. "From this," reports the Curtis Publishing Co., "it may be concluded that the building industry has an opportunity to expand housing markets provided more families can be convinced that home ownership represents a long-range saving in shelter cost and provided, further, that the industry is in a position to substantiate these claims." This will necessitate a real selling and promotional program.

Of pertinent interest is one of the Curtis Publishing Co. charts which showed from whom prospective home owners expect to obtain their homes: 30.6 per cent will go to a real estate agent, 20.2 per cent will go to a builder, 18.4 per cent will consult an architect, 11.3 per cent will go to their bank, 5.0 per cent will go to a building materials dealer, 9.9 per cent will go to other sources, 6.0 per cent don't know where to go. No other major industry depends so much on an automatic market as does the Home Building Industry.

Each year, the economists of the industry prognosticate the future volume of the industry by some magic formula which result equals the number of new dwellings or the new housing market. Right now these economists of the industry are enjoying a field day. There is greater unanimity of opinion than in a decade; we are to have from at least 600,000 to 2,000,000 new homes per year for the next 10 years. The Home Building Industry is confidently preparing to sell its lumber, shingles, roofing, insulation, hardware, paint, etc., and apparently confident in these predictions.

For the moment, the Home Building Industry seems to have forgotten that back in 1932 these same prognosticators, equally positive, declared that all signs guaranteed a minimum volume of 500,000 new homes in 1933. But, somehow or other, people were unaware of or ignored the formula and bought automobiles instead. For, only 54,000 new homes were built in 1933, an all time low for the industry. Again in 1938, only 315,000 units were built against the million predicted, but the automobile industry topped three billions of dollars and continued on to five billions of dollars in 1941. Yet, when faced with the same recession factors as the Home Building Industry, the automobile industry, in 1937, raised its advertising budget to 53 millions of dollars for new cars and an additional 47 millions for tires and accessories; while, in 1937, every traceable bit of advertising for bath tubs, stoves, insulation, lumber, and the whole 30,000 items of the Home Building Industry dropped to 9 millions of dollars.

The Home Building Industry should do a 15 billion-dollar annual volume. And the postwar problem of the country demands that it do so, but it is a moot question whether the experience of 1932 and 1937 will not again be duplicated. The potential will become an actual market only to the degree that the Home Building Industry competes successfully with such mass production industries as the automotive, radio, etc., for the consumers' dollar—by the use of basic policies that might be expressed in a formula, which could be called, "The American Business Success Formula."

Business has only one justification for existence, and that is to serve the consumer in his needs and desires for conveniences and luxuries. If business is to be successful under a competitive economy, it must continuously translate luxuries into conveniences, conveniences into necessities, and reduce the real cost of necessities in terms of consumer income. To say this more simply, business must provide "More for less money," while at the same time paying higher wages. This fortunately is almost universal practice on the part of successful American business. A thousand and one industries have achieved this goal and are achieving it every day—automobile, refrigerator, oil burner, etc. These industries did not achieve the goal of a better standard of living for less money at higher wages over night. The process was one of long, hard, analytical thinking by management followed by creative thought and action. In order to envision the opportunity for the Home Building Industry, one should have a clear understanding of "The American Business Success Formula."

Let us use the automobile industry as an example of what has happened to hundreds of industries in the last generation. Picture the automobile of 30 years ago and the manufacturer and dealer of that time with their decentralized manufacture, high costs, and inefficient retailing. Out of hundreds of makes of cars, a very few leaders survived because they alone applied production line engineering to the manufacture of cars. Moreover, instead of depending on livery stablemen, bicycle shop proprietors and implement dealers as distributors, they set up a pattern for retailers and trained these and other local factors in ever more efficient distribution line engineering. With increased efficiency in both production and distribution, costs were automatically reduced and volume and profits increased. With these larger profits, they paid increased dividends and tax bills, better salaries and wages to their employees.

Then began the great educational campaign of sales promotion and advertising, backed up with deferred payment plans, which made every American family want, and an increased number able, to purchase this new form of transportation. This promotion brought greatly increased volume of motor car sales and still greater savings and profits. Part of these profits were devoted to research which resulted in new inventions and technological progress. As the product of this research, major reductions in costs were made possible, and when these savings were passed on to the consumer in lower prices, volume increased and the whole process was repeated. As a consequence, today's automobile is at least twice as good a car and can be bought for less than one third of the cost of the automobile of thirty years ago.

It is vitally significant that in every instance where this formula has effected lower consumer costs, increased sales volume has been obtained. The formula has worked and is working in practically every important American industry except Building. When this formula is applied, it will not only do for the Home Building Industry what it has done for others, but it will also have a fundamentally beneficial effect on all American business.

As a result of the need and opportunity described in the foregoing pages, the Home Building Industry

Package Selling Retailer has evolved in the industry during the last 10 years. Prior to 1935, there were a few notable pioneers, but today practically all building industry retailers will at least accept this principle even though many do not apply it. The only road to adequate net profits in building material retailing is the dealer-controlled sale direct to the consumer of the complete unit, properly financed. The organization that does not accept and apply this fundamental operating principle is in danger of elimination over a period of years.

The proper organization in the Home Building Industry to apply this operating principle involves more than retailing in the accepted sense. Furthermore, we must not lose sight of the fact that both production and distribution are primarily local in the housing industry. With this in mind, the following principles are presented as a premise to forming such an organization.

1. The building industry's product is a complete unit; i.e., packaged homes or improvements wherein either building materials are assembled and fabricated or prefabricated units are assembled on the owner's property by construction labor and delivered to the consumer ready for use.

2. The building industry's customer is the ultimate consumer—the family that wants improved housing.

3. The building industry's basic policy must be consumer satisfaction, because it is the only road to industry profits.

4. All profits come from sales to consumers.

5. Increased profits come from more profitable sales to consumers.

6. More profitable sales to consumers result from increased consumer satisfaction plus aggressive sales work.

7. The consumer needs better housing; the manufacturer needs an outlet for his products; the dealer needs a return on his investment; the contractor, architect, realtor, and building trades need profitable employment of their services; and the financier needs an outlet for his money.

8. John Q. Public is not interested in sticks and stones; he is interested in a finished package with responsibility for good design, quality materials, sound construction, safe and sane financing, a proper site and a pre-determined price.

9. Only group organization can deliver what the consumer wants; there must be a local integration of the functions and factors of material supply, construction, architecture, building sites, and financing.

10. In order to secure its rightful share of the consumer dollar, the building industry must organize adequately to sell and service the consumer.

11. This will involve merchandising through one central headquarters where packages of the industry would be displayed and sold by competent salesmen.

12. Creative, dealer-controlled selling of housing packages is the essence of the problem, for only sales can bring idle production capacity and idle money together.

Summarizing, what is needed is an effective retail establishment with a system for integrating and coordinating the various functions and factors of the industry, a method of educating management and salesmen and the provision of a "one-stop" building industry package and construction service to the consumer.

The specifications for an organization which would have the physical and psychological bases for locally applying these principles are:

1. Financial responsibility;

2. Ample warehouses, offices, display rooms, and physical equipment to store, show, and deliver the products of the industry;

3. Eventual centralization in one inventory of all the materials going into small construction;

4. Complete materials, sales and service to industry and industrials;

5. Complete package supply to consumers on a one-stop service basis;

6. Management and sales management trained in scientific marketing;

7. An adequate sales organization thoroughly trained and operating on an incentive basis;

8. An aggressive advertising and promotion program to educate local consumers;

9. Installment payment merchandising not only for new homes, but also for all other building packages;

10. Selling from full-size models (inventory homes), priced to include financing costs to demonstrate the plus values in today's homes;

11. Headquarters for a completely integrated service organization of all local factors necessary to serve the consumer completely; and

12. A policy of improving the coordination of all factors and functions involved and of curbing existing industry wastes.

In short, the effective retailer will operate a modern department store of housing, merchandising, and advertising "complete packaged" homes, rather than the items from which they are built or with which they are equipped, backed with full responsibility for quality and service. Thus, the American family will know why and how it can afford to buy, and where it can buy and from whom it can buy its own home.

The significance of the home to the American family is illustrated in the following prize-winning letter which Johns-Manville received in a contest it sponsored a few years ago on "What a Home Means to Me":

> "Being a housewife, my social security number is not recorded in Washington—'But I have one.' It is the number of the front door of my very own home. That is what 'Home' means to me—'Security.'
>
> "When one buys a home, he plants his roots deeply and that blessed feeling of solidity is well worth the sacrifice it may cost.
>
> "My home is as a fortress, defying the forces of inflations and deflations, depressions and recessions.
>
> "True, the market value is affected, but the 'Home' value is always 100 cents on the dollar, with a generous dividend of security."

DISCUSSION

E. R. Hintz presiding

C. L. EBBERT[1]: Do I understand this packaged home to be so fully complete that it would also contain the foundation, masonry units, and all other materials that go into the home?

H. F. LOTZ: Why not? The packaged home is not necessarily a prefabricated house. The packaged home is a complete home delivered to the customer starting from digging the hole in the ground to occupancy. The customer wants a finished, complete job, so the key can be turned over to him and he can move in.

A. W. GAUGER[2]: What would the cost be?

H. F. LOTZ: I would say that under present conditions below $10,000, which might have been $7000 in 1941.

J. E. MACALEER[3]: This is a housing and heating conference. I would like to ask, has there been provision made for the type of heat, kind of heat?

H. F. LOTZ: The only thing we have tried to preach is responsibility. Whoever that packaged home dealer may be, whether builder, lumber dealer, or contractor, he must have responsibility; he should have products that go into the home that are reputable products, regardless of whether coal-, oil- or gas-fired.

C. L. KNIGHT[4]: Are the plans for these packaged homes standardized, or is there a wide-range of selection in type of house?

H. F. LOTZ: A packaged home can be a home designed by an architect so long as the per-

1 Executive Secretary, Contractors and Builders Exchange, Reading, Pa.

2 Director, Mineral Industries Experiment Station, The Pennsylvania State College.

3 Salesman, J. M. Brunner & Co., Philadelphia, Pa.

4 Manager, Winslow-Knickerbocker Coal Co., Baltimore, Md.

son building it completes it in order that the customer does not have to do the shopping and making contacts.

J. H. KERRICK[5]: I have a son just back from overseas trying to buy a home in Philadelphia. Weekend before last he saw a lot that appeared to suit his purposes so he went to the owner of the lot and offered a price for it. The owner would only sell the lot on the condition that he, the owner, would be given the contract to build the house. A conditional purchase of that order would not be very pleasing. The owner happened to be a builder. I recommended that my son forget it because there was no limit to what could have happened to him.

H. F. LOTZ: I would have done the same thing.

[5] Fuel Engineer, The Philadelphia and Reading Coal and Iron Company, Philadelphia, Pa.

The Relationship Between the Builder and the Public

By Harry M. Vawter*

THE SPECULATIVE home builder is a big time gambler; likewise, the department store owner. The department store owner, however, spreads his risk over many types of merchandise for different uses, whereas the speculative builder takes his entire risk on merchandise for one purpose only—a house to live in. The successful speculative builder is perhaps one of the shrewdest merchants in America; he has to be or he ceases to exist. He makes a careful study of his chances and eliminates, as far as possible, all those things which may work against his success. He follows the time-tested policy of the successful department store owner—a policy which, although generally known, is disregarded far too often. He determines what the public wants in advance and proceeds to make it available at a price which allows him a reasonable profit. Furthermore, he knows that quick doom faces him should he try to give the public *what he thinks it should have,* whatever the cost. (Incidentally, this latter type of thinking is responsible for most commercial failures.)

Let us, therefore, examine a speculatively built house in order to see what the public wants, or for what it is willing to lay down good money. Besides, let us accompany the builder-salesman as he shows the house to a husband and wife—prospective buyers. It is assumed the lot is of satisfactory size and the house is properly placed on it. The front entrance must be attractive and inviting, and it is. Inside the front door and just off the hall there is an ample coat closet and an attractive downstairs powder room and lavatory. You are a little surprised at the attractiveness of this lavatory. Don't be, for the builder knows what he is doing, and loses no time in showing this room to his prospect's wife. He knows she will be enthusiastic, will immediately think of the problem of getting the children cleaned up when they come in, and about what a nice place it will be to show her friends when they visit her. Next, the prospective buyers are shown the living room and the arrangement of wall space and electric outlets in the baseboard. The builder may even suggest the possible location of certain pieces of furniture, but not much time is spent here. Now, they move to the dining room where the living room routine is repeated.

Following this, they enter the kitchen. First, however, the party is shown the breakfast nook and told all about how convenient it will be, how it will save time in the morning and at noon when the children are home for lunch, and how it will save the rest of the house. The builder will point out all the electrical outlets, how their locations are just right for those table appliances, how everything is calculated to save steps and make the housework easy and convenient. That the prospect owns no electric appliances for the table makes no difference to the builder, for he is selling convenience and economy of labor. The next move is to turn to the kitchen. As our party turns the builder says, . . . "This is a streamlined kitchen; it has everything to make work enjoyable. Your wife spends more hours per day in the kitchen than any other room in the house, and we believe we have thought of everything to make things easy for her in beautiful surroundings." You are shown a Magic Chef stove with automatic controls—the latest model—all the closets, the sinks and drainboards, and a place for the washing machine; the builder assumes, of course, that you have one. He shows how at some future time you can install an automatic dishwasher and garbage disposal unit. "You see," says the builder,

* General Manager, Bituminous Coal Institute, 60 East 42d Street, New York 17, N. Y.

"we have made provision for all these things, including this recessed place for your electric refrigerator."

Does this wife like the house? She starts to live in it immediately.

Now, the party goes to the second floor where it is shown the bedrooms, each with the proper amount of wall space for good arrangement, ample closet room, a good linen closet, cross ventilation, electric outlets, and so on. Next, they see the bathroom, how the tub can be converted into a curtain shower and how nice the porcelain is. "The finest equipment made," this builder-salesman remarks. "We always use Standard Sanitary." Or, he may say, "Crane" or "Kohler." But why does he mention one of these names? The answer is simple: he believes the customer will know them and the prospective buyer will believe he is getting the best of everything.

Having inspected the second floor the party returns to the first floor. And what does the prospect's wife do? She walks right back into the kitchen because push-button living has captured her imagination and she loves it.

Usually at about this point the builder turns to the husband and says, "Would you care to see the basement?" You have already noticed that the builder has not taken his prospects to the basement in the same way he led them into the other rooms that he wanted to show them. Why does this happen? There seems to be only one answer: a basement has no glamour. Although the heating plant includes an automatic oil burner, which the builder can describe as "automatic heat," it still has no glamour, at least to the wife. Moreover, the builder knows that it is the prospect's wife who will finally influence the decision as to whether or not a particular house is bought.

Who is responsible for this basement which has no sales appeal? It can be laid at the door of the fuel, the combustion, the boiler, and all associated heating industries. None of these seems to realize that the public, not the wholesaler or dealer, is the customer. The big task facing the heating industry does not lie with the builder; it is to sell the public. If this is done the builder will come along automatically.

Let us, therefore, discuss the public, and where the coal industry stands with relation to the public. It is true that the oil and gas industries have very definitely impressed the advantages of their fuels on the public mind; notwithstanding, they haven't made as much progress in this direction as have the Sherwin-Williamses of paint, the Anacondas of brass plumbing and copper gutters and the Johns-Manvilles of roofing. One may prove this contention simply by comparing the number of advertising signs for paint, plumbing or roofing on new homes with those for oil or gas heating. The ratio is pretty heavily in favor of the former. Is it ten to one? Twenty to one? This is encouraging, for it means that although the coal industry has a hard selling job ahead, it is not impossible. The door hasn't closed in our faces.

People still buy houses that are coal-heated. Unfortunately, however, the first thing many of them think of is "How soon can I afford the cost of conversion?" Even this negative situation has its brighter side. Notice that I said "cost of *conversion*"; strangely enough, this seems to be the only consideration in many cases. People generally seem unaware that these competitive fuels will cost them more money than coal month after month, year in and year out. Still, it isn't that savings on fuel cost are not important to them. A recent survey among renters who are prospective home buyers disclosed that the major reason given for home ownership was: "It is more economical." People are interested in cutting down expenses; but, no one has ever told them that, after taxes and mortgage payments, heating is the *next major item in home upkeep*. Perhaps the coal industry should bring this to their attention; also that coal is the *lowest cost, most economical fuel*.

We are all aware that the desire for home ownership has never been so widespread. Never has the demand for homes been so great, and the supply so small. The stoppage of all home building during the war, combined with the high incomes which the war brought to so many, has created a tremendous backlog. The lifting of government restrictions on building just a month ago should mean that a housing boom will get under way this coming spring. Many competent observers expect it to last as long as 10 years.

What is this going to mean to the coal industry, and to manufacturers of coal-burning equipment? One thing it means is this: there is a crying need for a vigorous, constructive program for selling *coal-heat;* furthermore, it isn't a job that can be postponed. The coal industry has a long, hard road to hoe. The selling program ahead is going to be tough and uphill all the way, since our competitors have almost a twenty-year start. To overcome that lead our effort has to be strong and *concerted.* There just isn't time to sell X Coal against Y Coal, or X Stoker against Y Stoker. The thing that must be done is to sell *Coal* against Oil and Gas as a better domestic fuel. If the coal industry does this, the rest will take care of itself. And we *can* do it. Of course we can. That's why we stay in the coal business in one way or another. Yet, we must use a successful formula.

Let us look at the method used by our competitors in taking the market away from coal. How have they sold their fuels? What was their broad approach? They have made a lot of claims, most of them true. For example, they have said that their fuels are *clean;* that they are *odorless.* Yet, the one claim that encompasses all others is this: they have called their fuels *automatic.* They have done it so long and so loudly that the idea is established in the public's mind. However, this was never accomplished by any single oil company, or burner manufacturer, or for that matter by any single utility company. It was an industry-wide program with everyone in the field shooting at the same target. Otherwise, without such *concerted effort* it never could have been done. These industries performed the task *together* and it has been conducted with a single selling objective. Mr. Average American doesn't want to be bothered with taking care of his furnace; therefore, the *Automatic* idea appeals to him. It sells oil and it sells gas; it is a proved method.

But, what about coal? In general, the coal industry never has sold its product as an *automatic* fuel. Perhaps this has been done by a single coal company, or a few coal-burning equipment manufacturers; but they are isolated cases. Now, if ever, is the time for everyone in the coal industry to start moving in the same direction, because it is only by concerted effort that the industry can hope to create any mass effect on the public mind. If such action were a reality, what should be the selling theme? What better one than that used so successfully by the coal industry's competitors. Is there any reason why coal cannot be sold as an automatic fuel? Of course not, when it is used with modern stoker equipment. Suppose every organization represented at this conference directed its selling and advertising efforts along the "automatic fuel" line, wouldn't it be reasonable to assume that the combined weight of this effort would make itself felt sooner than if we all went our separate ways?

The Bituminous Coal Institute has been directing efforts toward this new market for almost two years, with a series of advertisements in the so-called Shelter Group magazines—American Home, Better Homes & Gardens, and Architectural Forum. Throughout the campaigns, every single advertisement pointed out that coal, when used with modern stoker equipment, is an *automatic fuel.* Beyond all this, there is just one more point that is of paramount importance in any advertising aimed at the public. It is: keep the message simple, keep it understandable to the man in the street.

At this juncture, I am reminded of an experience some years ago when I was working with one of America's leading corporations. We were about to announce a new radio set. Everyone in the organization was experiencing the problems which always accompany such an event. The engineering department particularly had suffered months of anguish and nausea. Finally, when their labors bore fruit they were as proud as the usual new father, and just about as glassy-eyed. Nothing would do but to bring such world-shaking news to the public *in detail!* As a result the advertising department protested, and the sales department protested, but to no avail; the proud papas couldn't be stopped. The advertisement appeared as the engineering department wanted it; it told readers all about the wonderful new flat frequency-response curve, a product of their laboratory. The public, however, wouldn't buy a flat frequency-response curve.

Now, I have no argument on account of the presence of many geniuses in the laboratory. I won't even argue about the advantages of a flat frequency-response curve. My argument is concerned with the way the public was told about the new radio. The public doesn't know what a flat frequency-response curve is, any more than it knows what ash fusion point is, or what a chain grate is; moreover, the public doesn't care. However, in radios, the public is interested in a good looking piece of furniture that will talk naturally and, of course, sell at a price it can afford to pay. In home heating, the public is interested in: "How can I save myself trouble?" and "How can I save myself money?"

It should be remembered that these are the same people who wouldn't buy a flat frequency-response curve. Neither will they buy Btu's nor ash content, nor worm gears, nor spreader types; but they *will* buy *comfort,* they will buy *convenience,* and they will buy *economy.* Why isn't it sensible to give them what they want? Why try to buck them? Our task is going to be difficult enough as it is. It is not going to be accomplished in six months or even a year. The coal industry might as well realize the extent of its task and take the long view of the problem, for the advantage of our competitors' 20 years of progress cannot be erased in just a few short months.

Still, what is to happen to the market for coal until the time when our efforts are felt? By and large, it is going to be competitive, and there is little if anything that can be done about the situation. The loss, however, is not likely to be as great as might reasonably be expected.

In this connection, I would like to quote from a comprehensive survey of the home market conducted early this year by Crossley, Incorporated, under the sponsorship of Architectural Forum. In summarizing the results of the survey this statement was made:

"Although a third of U. S. families are interested in buying or building some time in the future, only 7.5 per cent can fairly be called Good Prospects for the next two or three years. Of these, *only 1.5 per cent* are Sure Prospects in the *immediate* market."

From the statements gathered by the interviewers, fear seems to be the one factor which will make the coming year a light building period compared with the several years that will follow. This fear centers around: (1) possible shortages of materials and labor, (2) possibility of inferior or substitute materials, and (3) possibility that new housing developments will not have reached the market.

Furthermore, with reference to the 1.5 per cent of Sure Prospects over the coming year, the survey also points out:

"If all these Sure Prospects decide to buy *new* houses a little over 550,000 houses will be built. But experience shows that ordinarily 60 to 70 per cent of all prospects settle for older houses."

Thus, over the coming year, coal-heat is faced with losing the major portion of a market ranging somewhere between 140,000 and 220,000 new houses, the prospective owners of which can pay for and will demand automatic heat. Despite this, it is the 1947 and 1948 markets, as well as those for 1949, 1950, and 1951 and even beyond, which represent the *big* melon. The coal-heat industry should get its slice by immediately launching a far-reaching and comprehensive program that will make the public conscious of two fundamental facts about coal:

1. It is an *automatic fuel.*
2. It is the *lowest cost, most economical* fuel.

The Bituminous Coal Institute is at work right now, and expects to have ready in the very near future, a plan for the organization of coal merchants' associations which will put them on a competitive basis with other fuels. This, however, is only one of many factors which must be brought to bear on the problem, to bring about its successful solution. Besides, these factors rest in the hands of individual companies in the coal and coal-burning equipment industries. In a good many cases, they rest in *your* hands. In any event, every one of you can go back to your organizations and help to put such a program into effect.

In conclusion, and at the risk of sounding dramatic, it is my belief that at the present time coal is standing at the crossroads. There are only two courses open, for nothing ever stands still. Either we go down, or we go up. We *can go up;* we *can* regain lost ground and put coal back where it belongs. We can get the lion's share of the new home market, but we must do it *together.* All of us must pull in the same direction.

Which way are we going? Up—or down? This decision will be made by the coal industry and its affiliated industries.

DISCUSSION

E. R. Hintz presiding

A. J. JOHNSON[1]: We all enjoyed the very interesting paper, but I think there is danger in assuming that automatic heat will solve all problems. It is natural that at a conference of this kind, we would talk of automatic heating because so many of those present want it ultimately.

However, if we educate people to want automatic heat at present consumer ratios, we get one out of 14 for automatic coal, the other 13 go to gas and oil. For instance, with all of the advertising, promotion, research, etc., there are only 150,000 anthracite stokers in the field as against 6,000,000 hand-fired furnaces using anthracite. Thus, the bulk of the business is hand-fired.

Couldn't we have a line of demarcation above which we would talk automatic heating and below which we would try to make hand firing more convenient and more acceptable?

It seems that the answer to this question is one of economics. When you get down to the average income bracket, you are going to find that the large majority could never afford fully automatic heating. We should, therefore, be concerned about the people who want automatic heat because they are probably the ones who can buy it, rather than trying to bring in entirely new groups.

Most people don't fully realize that coal can be burned automatically. The coal industry can and should tell the public that if it wants automatic heat, coal can give it.

[1] The Anthracite Industries, Inc., 101 Park Ave., New York 17, N. Y.