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Johns-Manville corporation

Heat; the dramatic story of man's age-old struggle to control nature's most powerful force.

[redacted]

Heat

THE DRAMATIC STORY OF MAN'S
AGE-OLD STRUGGLE TO CONTROL
NATURE'S MOST POWERFUL FORCE

◆

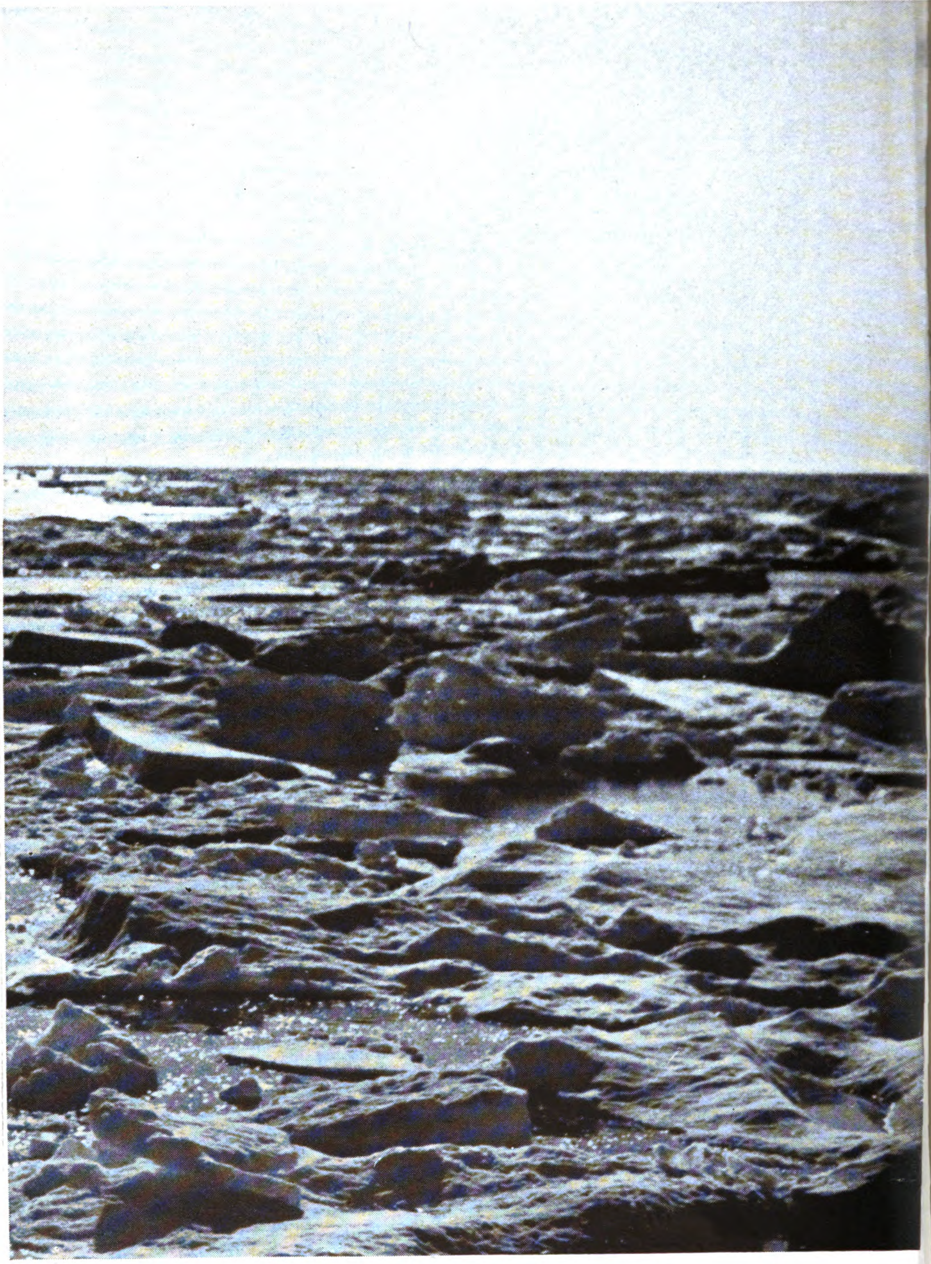
From its more than three-quarters of a century of experience in the art and science of heat conservation, Johns-Manville drew the basic concept for a sound motion picture "Heat and Its Control." During the filming of this picture it was found that the wealth of material on this subject, gathered together during many years by Johns-Manville engineers, research scientists, and others, was far more than could be compressed into a fifty-minute movie. Thus, "Heat" came to be published as a supplement to "Heat and Its Control." Both the motion picture and this book are presented with the hope that they may contribute to the progress which industry is constantly making in the more effective utilization of heat.

◆

Heat

THE DRAMATIC STORY OF MAN'S AGE-OLD STRUGGLE TO CONTROL NATURE'S MOST POWERFUL FORCE

JOHNS-MANVILLE
22 EAST 40th STREET • NEW YORK, N. Y.



Without Heat Man Perishes . . .

In barren polar wastes, no green thing grows; no living sounds break the frozen silence of the Arctic regions.

HEAT . . .

Men Worship and Ponder a Great Enigma

SINCE time began, the sun has been the world's fundamental source of eat—or energy, as science defines it.

Thus, if one day a curtain were to be ropped abruptly between the earth and un, cutting off this supply of heat, the esult, to say the least, would be catasrophic.

A vast pall of cold and darkness would nvelop the earth like a shroud, drawing he heat from the ocean and covering it ver with a thick sheet of ice; blighting he growth of all vegetation with an icy ouch; and slowly, inexorably throttling ut all life.

Man would be the last to go. For during the last century or two he has discovered the energy that the earth stored up during millions of years in the form of various chemical compounds such as coal, oil and natural gas. This energy under the relentless pressure of the circumstances, man would no doubt carefully husband to cook his food, to heat and light his dwellings, to run his dynamos, and, in short, to keep his complex civilization alive, postponing as long as possible the inevitable end.

Stores of Energy Squandered

Man, however, sees no chance of the life-giving rays of the sun being suddenly cut off, so with profligate hand he spends his stores of available energy, apparently indifferent to the fact that even though today the process of storing up new supplies may be taking place in the few remaining uninhabited parts of the world, it will take additional millions of years for any appreciable quantity of this energy to be turned into usable form.

In this apparent indifference man ignores almost entirely the fact that within a few generations the stores of energy now available may be completely dissipated.

Fortunately, however, this picture is not quite as black as we have painted it. For although most of us, like the grasshopper in the fable, give no thought to tomorrow as far as this problem is concerned, there *are* men who are devoting their lives to the conservation of this available energy, not only from the standpoint of making our present supplies last as long as possible, but also from the standpoint of getting a maximum of service from the energy we do use, and thus reducing production costs which have become a tremendous factor since the upbuilding of our present complicated and highly specialized industrial civilization.

These men, at work on this problem for comparatively few years, have made great strides. Evidence of this is that from the Johns-Manville Research Laboratories and factories alone, have come developments in the art and science of heat conservation that save American Industry what is conservatively estimated at 250 millions of dollars annually.

In ancient times man worshipped the sun as his only source of heat and light. Later, when he learned to kindle fire, the flame became the object of his religious veneration.

Fascinating is this story of the part that research has played in conserving man's stores of available energy. As fascinating, perhaps, as was the subject of this mysterious force—heat—to the early Greek philosophers in the time of Epicurus and Democritus.

The genius Galileo, who was the first experimental physicist. Galileo, in order to further his studies of the mystery of heat invented, in 1600, the thermometer.

These men spent long hours of thought and study in trying to determine the true nature of heat. But being essentially philosophers, and thus being given to studying nature from a standpoint of logic rather than from an experimental point of view, they arrived at the faulty conclusion that heat must be a material substance of some nature.

Galileo's Thermometer

In fact it was not until the genius Galileo began experimenting in an attempt to solve the mystery of this vital force that any real progress was made. Galileo, faced with the realization that man possessed no senses which enabled him to determine temperature accurately, was forced to invent an instrument that could be used for this purpose.

This instrument, which he succeeded in developing in 1600, is what we know today as the thermometer.

At the time of its invention, the thermometer was thought to possess the ability to measure the quantity of heat in a substance. In reality, the thermometer measures only the temperature of a substance, and not the *amount* of heat that it contains. This extremely important point we will discuss in more detail later on in this story.

That Galileo did his work well, however, is evidenced b the fact that the the mometer he invente with certain refine ments, is the same typ used as the standard o accuracy by the U. S Bureau of Standar today.

Galileo's thermomet used expanding gas t measure temperature be tween two arbitraril chosen points. Th scales with which w are most familiar ar the Fahrenheit, name after its inventor, an the Centigrade. Fahrenheit chose as hi low point the temperature of a mixture o salt and ice, and called this zero. Hi high point was the temperature of th human body, set at 100°. Normal bod temperature is now known to be 98.6° probably because we now have instruments capable of making more refine measurements.

On the Centigrade scale, zero is th temperature of melting ice, and 100° th boiling point of water. On the Fahrenhei scale water freezes at 32° F., and boils a 212°.

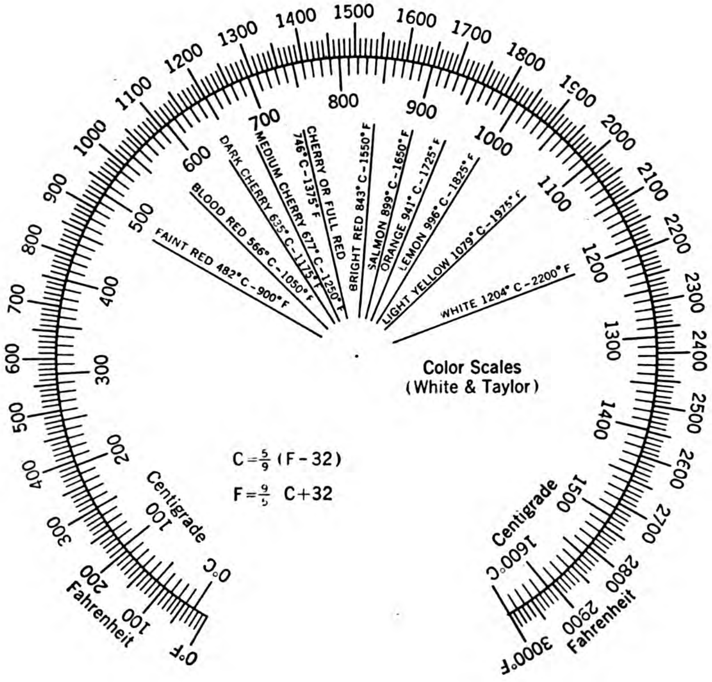
Caloric and Phlogiston

For centuries after the thermometer became available, no one could conceive tha what it measured was anything but tangible. Thus, Galileo's invention gav added impetus to the idea that heat was a material substance. This substance wa supposed to possess the ability to permeate all material bodies, and to be able to transfer itself from warmer to colder bodies. Followers of these theories arbitrarily named this substance, the two names in widest use being "caloric" and "phlogiston."

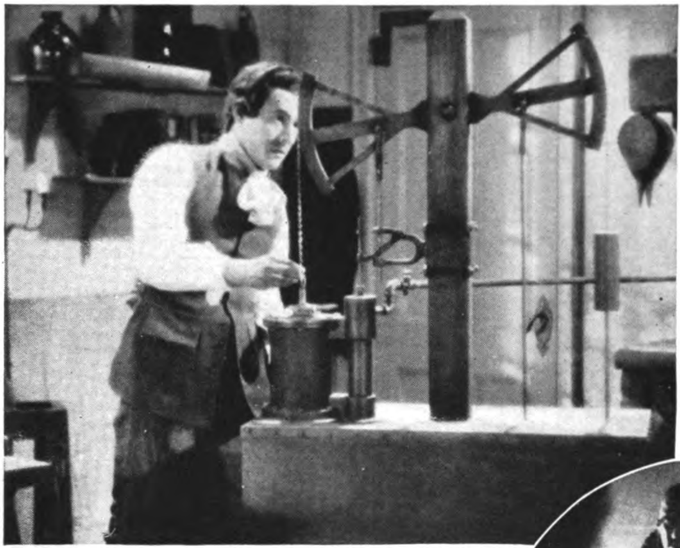
Joseph Black, a Scottish chemist, threw the first bombshell into the camp of the followers of the phlogiston and caloric theories. by discovering that two substances of the same mass, and at the same temperature, held different amounts of heat. The quantity of heat a substance can possess for each unit of mass at a given temperature is expressed by a constant, characteristic of the material. This constant is known as the material's specific heat. Water, for instance, has the highest specific heat of all, and we use it in the radiators of our automobiles because it possesses this ability to absorb and carry off more heat than any other fluid. If you leave an alcohol-water mixture in your car's radiator during the summer months, the motor will heat up far more rapidly than if the radiator is drained of this mixture, and refilled with plain water, because of the inability of the mixture to absorb and carry off heat as rapidly as plain water.

Black Discovers Latent Heat

Black also discovered that no matter how fast heat was added to a combination of melting ice and water, the temperature could not be raised, if the combination was kept stirred, until all of the ice was melted. He also discovered that by adding heat faster to boiling water, the temperature of the water was not raised even a fraction of a degree. The water merely boiled away faster. This hidden heat, he named *latent* heat because it did not cause any rise in temperature.



CENTIGRADE-FAHRENHEIT CONVERSION CHART



When James Watt perfected the first practical steam engine, it was the beginning of the end of back-breaking toil and drudgery that had been man's lot from the beginning. The steam engine shown at the left is an exact replica of Watt's first engine. Both of these scenes are from the Johns - Manville sound motion picture, "Heat and Its Control."

A particularly apt pupil and able assistant of Black was a man named James Watt. Watt, seeking a use for the knowledge he gained from Black and from his own experiments, turned to the steam engine that Thomas Newcomen had invented some thirty years before.

Newcomen's engine had been a crude and clumsy affair, useful to its inventor, but too imperfect, from a mechanical and thermodynamic standpoint, to have any wide practical application.

Watt's Accomplishment

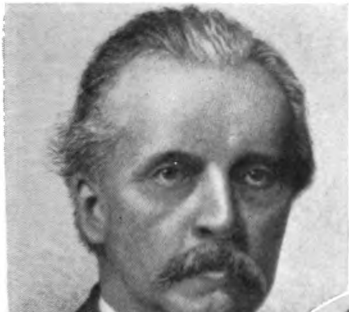
Watt earned himself undying fame by perfecting the first practical steam engine, which usefully converted heat into mechanical work.

His accomplishment was indeed impressive. And it was of tremendous importance because it stimulated the scientific world to renewed investigation of the true nature of heat in order that they might further harness it to alleviate the burden of back-breaking toil that had been man's lot for countless centuries.

It is interesting to note, however, that not all scientists in those days had been led astray by the belief in the materia nature of heat.

Such men as Descartes, Amontons, Boyle, Francis Bacon, Hooke, and Newton believed that heat was mechanical, or, in other words, due to motion within the substance. But their results were arrived at by pure reasoning. Their primary interests lay in other fields. They might have verified their theories if they had resorted to actual experimentation, and observation.

On the other hand, Count Rumford observed first and then theorized. While engaged in boring cannon he observed that the cannon became hot. This led him to place a cannon in a vat of water during the boring operation, and when



Above: **Robert Mayer (1814-1878) was born in Heilbronn. He was a doctor of medicine, but is recognized for his work in proving the mechanical nature of heat.**

the water boiled due to the heat engendered by the friction of the boring tool, he deduced that heat was a form of motion.

His experiments proved the first serious opposition that the materialistic idea of the nature of energy had, and in 1804 he wrote to a friend:

"I am satisfied that I shall live a sufficiently long time to have the satisfaction of seeing caloric interred with phlogiston in the same tomb."

He did not, however.

Above: **James Prescott Joule (1818-1889) was born at Salford, near Manchester, where he was the proprietor of a large brewery. He became an eminent physicist.**

Old Theories Clung To

The scientists of his day, while their beliefs must have been shaken somewhat by Rumford's experiments, clung tenaciously to the old theories. It was, in fact, many years after his death before the experiments of such men as Mayer, Joule and Helmholtz proved conclusively that Rumford's deductions concerning the mechanical nature of heat were correct.

These three men, Mayer, who was a doctor; Joule, a brewer, and Helmholtz, a physicist, experimented independently. And since each lived in a different country, and communication in that day was very slow, it was not until some years passed that it was found that they had all come to the same conclusions practically simultaneously.

Mayer is recognized for his work in proving the mechanical nature of heat. But when published, his ideas were so revolutionary, and contrary to what the world accepted as fact, that they were accorded a very cold reception. Because of this lack of appreciation for his ideas, Mayer lost his mental equilibrium, jumped out of a window in attempted suicide, and was committed to an asylum. Later, however, he regained his mental faculties and received at least a portion of the recognition to which his great work entitled him.

Below: **Herman von Helmholtz (1821-1894) was born at Potsdam. He was one of the discoverers, along with Mayer and Joule, of the theory of the conservation of energy.**

The second of these men was James Prescott Joule. Joule was a brewer by inheritance, and could have lived a very quiet and easy life, but with the restlessness of genius he devoted himself to physics and became most eminent in his chosen field.

Both Joule, and Herman von Helmholtz, the physicist, made known their discovery of the theory of the conservation of energy in the same year.

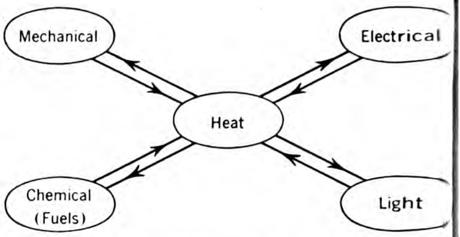
This was the greatest discovery which had been made toward the final solution of the mystery of just what heat is and it gave added impetus to the search for the answer to this question. But since the details concerning this search, which was made over a period of years by some of the world's most brilliant scientists, are not particularly important in this story, let us turn instead to an explanation of the theory of conservation of energy. Then we shall examine the facts about heat that this theory helped bring to light.

The theory of the conservation of energy in its essence is that energy can neither be created nor destroyed.

An illustration of this is the making of electricity from one of the sources of available energy such as coal.

The energy in the coal is changed into heat by burning. The heat applied to water produces steam which a steam engine converts into mechanical energy. This mechanical energy in turn rotates an electric generator, producing the electrical current which is transferred into light by the electric light bulbs in our homes.

When we carefully analyze the energy obtained in any of these transformations and take into account the heat generated by friction of the wearing parts and th heat accidentally lost to the surroundings we find that the same energy was obtained as was originally put in.



The theory of the conservation of energy is based the fact that energy can neither be created nor d stroyed. Any type of energy can be transformed in any other type of energy.

In all of these changes the amount o available energy was decreased by hea losses through lack of proper insulation through friction, and through heating o the wires carrying the current. These heat losses took their toll of the final amount of energy available for lighting the bulb, and were dissipated as unavailable energy.

Thus, we get a clearer insight int the tremendous necessity for the conservation of heat lest our entire stores o *available* energy be transformed into *unavailable* energy, and for the more selfish reason that by conserving valuable heat we lower production costs and thus enable ourselves to enjoy the fruits of the more abundant life that the machine age has brought.

* * *

Heat Is Nature's Most Powerful Force . . .

Uncontrolled, heat can become a raging monster of destruction—consuming everything in its path. Yet when heat is controlled and man is its master, it accomplishes most of the world's work.

THE ANSWER . . .

To the Riddle of Heat

"HEAT is not the clash of winds, not the quiver of a flame, nor the ebullition of water, nor the rising of a thermometric column, nor the motion which animates steam as it rushes from the boiler where it has been compressed. All these are mechanical motions into which the motion of heat can be converted. But heat itself is molecular motion. It is an oscillation of ultimate particles."*

To the layman, of course, it's pretty difficult to imagine that all matter is composed of molecules in a constant state of agitation, let alone the fact that heat itself *is* this motion. And it is pretty hard to believe that an iron bar, for example, held in the hand—something hard and heavy—is actually only a flock of little particles flying around at a great rate, constantly colliding and rebounding from one another much as billiard balls do.

But nevertheless, the modern concept of matter is that all substances are composed of minute particles in a constant state of motion.

Nature's Building Stones

In the case of a gas, the particles of which it is composed are far apart and move relatively large distances between collisions, at the astounding rate of more than a mile a second when the gas is at room temperature. In the case of liquids the particles are packed much more closely and their motion is more restrained. In a solid, the particles are still closer together and the motion is reduced to vibration about a point of equilibrium.

These particles, the fundamental building stones of nature, are atoms, or collections of atoms known as molecules.

For example, gold is composed entirely of atoms as are the other 90 know elements, while our most common substance, water, is composed of molecule made up of two hydrogen atoms and on atom of oxygen.

The Size of An Atom

To gain an idea of the extreme minuteness of these atoms and molecules, and the large number it takes to make up even the smallest visible amount of a substance, it is only necessary to realize that if each molecule contained in one cubic centimeter of water or less than one-sixteenth of a cubic inch was represented by an average grain of sand, we would have a cube measuring one mile on each edge.

Naturally, atoms and molecules cannot be observed even under the most powerful of microscopes, but their actions can be studied indirectly.

Particles of matter, microscopic in size yet large in comparison with either atoms or molecules, are continually bombarded by the molecules of the medium in which they are immersed. These particles are so small that the bombardment is not uniform, and the result is that they will move in the direction in which they receive the fewest impacts from the molecules. This movement may be observed with a microscope.

Robert Brown was the first to note this movement when in 1827 he observed the activity of particles suspended in a liquid. For this reason, this phenomenon is called the Brownian movement.

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* John Tyndall, in "Heat Considered as a Mode of Motion." Published in 1863.

The energy molecules possess due to his motion is called kinetic energy. The emperature of any substance is the measre of the average kinetic energy of the molecules composing it. Increasing this nergy by the addition of heat correpondingly raises the temperature.

Absolute Zero

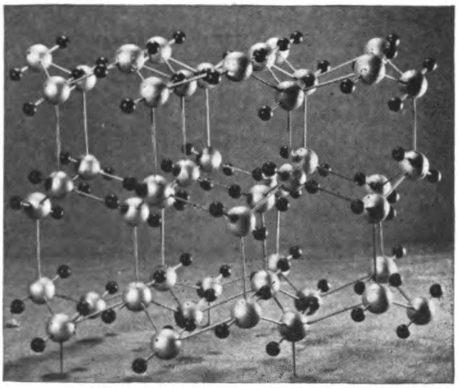
Naturally in cooling a substance, we ause heat to leave, thus decreasing the kinetic energy of the molecules of which t is composed. If we continue to chill a ubstance the movement of the molecules vill become slower and slower until the emperature will have dropped to what is known as "absolute zero," or —459.6° F.

No one has succeeded so far in reducing the temperature of any substance to absolute zero, but in liquid helium at —453° F., and in some few other substances this point has been approached.

In order to understand more clearly what happens when we add heat to a substance, thus raising its temperature, let us take, for example, a piece of ice. If we add heat to this ice, the kinetic energy or motion of the molecules increases. They move faster and faster in their relative positions, and the temperature of the ice rises to the melting point.

The unit in common engineering use for measuring this heat which we are adding to the ice is, of course, the British Thermal Unit, familiarly known as the B.t.u., which is defined as the amount of heat energy necessary to raise the temperature of one pound of water from 63° to 64° F. The scientific unit used in measuring this heat is the calorie, a name borrowed from the old caloric theory. One calorie is the amount of energy necessary to raise the temperature of one gram of water from 15° to 16° C.

When we have added enough heat to raise the temperature of the ice to 32° F., or zero degrees C., the ice begins to melt or to change its state. If the ice and water are kept stirred, there will be no rise in temperature as long as any ice remains. What is happening is simply this: The molecules of ice have reached the maximum speed possible to them in their relatively fixed positions, and additional heat is not causing an increase in their speed, but a change in their position, and hence, a change in state.



What appears here to be a child's plaything of balls and sticks pegged together is in reality a physicist's representation of the crystal structure of ice. The small balls represent hydrogen atoms, the large balls oxygen atoms. Together they represent a molecule of water.

The tremendous amount of energy necessary to cause this change in the relatively fixed positions of the oscillating molecules in a substance, is illustrated by the fact that the amount of energy necessary to change one pound of ice into water is 144 B.t.u., an amount sufficient to raise the temperature of the same amount of water from room temperature to the boiling point. Since the heat added to the ice and water is used entirely in changing the ice into water, there can be no increase in the kinetic energy of the molecules, and thus, no rise in temperature.

The housewife who wants to cool a liquid in a hurry adds a small cube of ice rather than cold water since one pound of ice at 32° F. in melting absorbs 144 B.t.u. without a change in temperature, while it would require 144 pounds of water at 32° F., rising one degree in temperature, to absorb the same amount of heat.

When the ice has been changed into water, any more heat we add will cause the molecules, now vibrating in new positions since the change of state, to oscillate more rapidly, increasing the temperature until the boiling point is reached.

Here a change similar to that occurring when the ice melted into water takes place in the transforming of water into steam. To make this change of state, 970.3 B.t.u. of heat must be added to each pound of water to change water at 212° F. to steam at 212° F.

The cook who wants to make use of this scientific fact will turn the fire down immediately upon bringing the water in a tea-kettle to a boil, since any heat that she adds will not raise the temperature of the boiling water a bit beyond 212° F. but will only succeed in changing the water into steam more rapidly.

If we add more heat after water has been changed into steam, the movement of the molecules is speeded up, and we have superheated steam. This steam in industrial use is of much more value in doing work due to its possession of a great deal more energy than saturated steam, which is steam at the boiling poin of water in temperature.

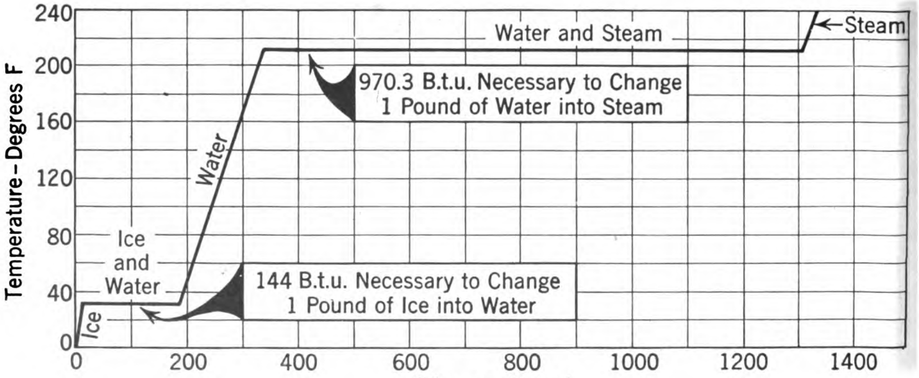
So far, however, we have discussed only what happens when heat is added to a substance, and have said nothing concerning how this heat is transferred.

Heat Transfer By Conduction

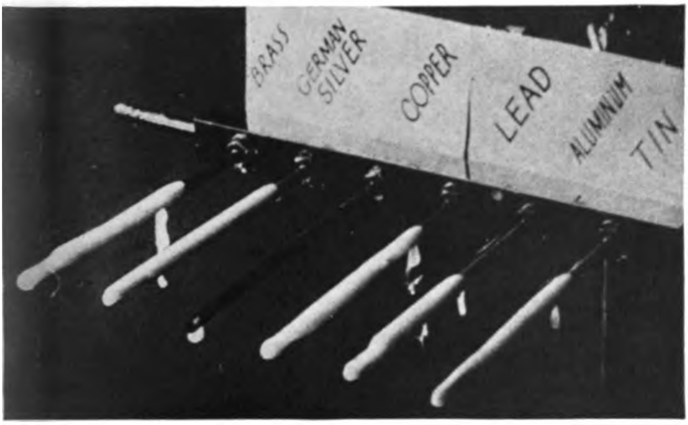
The transfer of heat can take place in three ways, by conduction, by convection and by radiation.

If you pick up an iron bar and thrust one end into an open fire, the molecules of the end of the bar which is in the fire will immediately speed up. These in turn will bombard adjoining molecules, causing them to speed up until all of the molecules in the bar are moving progressively faster and faster. This is transfer of heat by conduction.

Some of us remember—and very painfully at that—being talked into laying our tongue on the surface of an iron bar outdoors in freezing weather. The reason our moist tongue froze to the bar, and could be only removed by leaving a layer of skin on the bar, was because iron is what is known as a "good conductor," and the human body is a "poor conductor" of heat. In other words, the iron bar conducted heat away from the tongue so



Heat required to change ice at zero degrees F. to superheated steam at 240° F.



The wide variance in the thermal conductivities of various metals is shown by this laboratory test. The bars of metal, painted black, are covered with wax, then heated equally with live steam. The distance to which the wax melts is an indication of the relative conductivities of the different metals.

rapidly that there was no chance for heat from the rest of the body to be conducted into the tongue at a sufficiently high rate to keep the moisture on the tongue from freezing, thus gluing the surface of the tongue to the iron bar.

Practically all metals are good conductors, in fact they have the highest conductivity of any materials. But even in metals there is a great variation in the degree of thermal conductivity. Silver, for instance, is roughly seven times as good a conductor of heat as steel.

In some cases the spread between the conductivity of metals and non-metals is unbelievably great. For example, copper is approximately 220 times as conductive of heat as dolomite limestone, as can be seen by looking at the table of conductivity values shown herewith.

Heat Transfer By Convection

The second method of heat transfer is by convection.

Heat applied to a liquid causes it to expand, and thus to become lighter than the surrounding liquid. This heated liquid rises and the heavier, cold liquid replaces it nearer the source of heat. This process is repeated, and thus currents are set up continuously transferring heat. This is also true of gas.

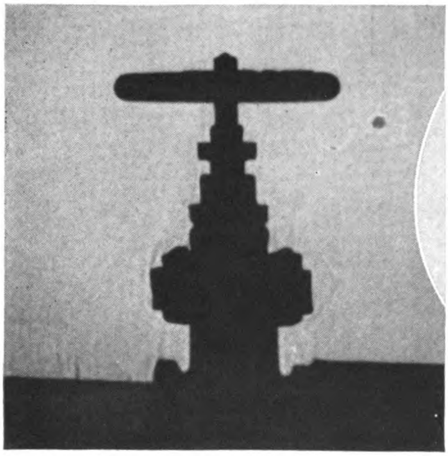
These currents are called convection currents, and can actually be observed in the case of smoke from a chimney, and the "heat waves" rising from the pavement on hot summer days.

In the case of wind, we can feel these currents which may be as gentle as a cool Spring breeze, or as thunderously powerful as those which whip the snow across the landscape during a blizzard.

THERMAL CONDUCTIVITIES

k = B.t.u. in./hr./sq. ft./degrees F.

Substance	Temperature, degrees F.	k
Silver	212	2880
Copper (pure)	212	2664
Aluminum	212	1428
Brass (60-40)	212	828
Zinc	212	744
Tin	212	408
Steel (mild)	212	396
Cast iron	212	336
Lead	212	237
Ice	32	15
Sandstone	104	12
Dolomite	122	12
Concrete (stone)	...	6
Oak	122	3
Diatomaceous Silica (natural)	212	0.6
85% Magnesia	212	0.49



Above: **This shadowgraph shows the convection currents set up by heat loss from uninsulated pipe (left) as opposed to insulated pipe (right).**

Above: **Convection currents set up by the heat from a flaming match which the research engineer is holding in his hand. Note, also, the shadow of the smoke from the cigarette which he is smoking.**

We take advantage of convection currents when we ventilate a room by opening the window from the top to allow warm air to escape, and from the bottom to allow cool air to enter.

A Great Fallacy

In this connection it might be well to mention that one of the greatest popular fallacies is that a so-called dead-air space is effective insulation against the passage of heat. For example, for many years it was thought that the hollow outside walls of a house provided adequate insulation against loss of heat in winter, and against the stifling heat of summer.

We know that this is false because strictly speaking there is no such thing as a dead-air space.

This is due to convection currents which are set up in such spaces unless the temperature on both sides of the space is equal.

Thus, in winter, when the home with hollow outside walls is heated, the heat from within the house causes convection currents to be set up in these hollow walls, and the heat thus transferred by convection from the inner to the outer surface of the hollow space, is transmitted by conduction through the exterior sheathing and finally wasted on the winter air. As a result fuel bills are much higher than if the walls were filled with a material which would eliminate transfer of heat by convection and at the same time be a poor conductor of heat.

Heat Transfer By Radiation

The third method of heat transfer is by radiation.

Stepping out into the sunlight on a warm summer's day, we feel the tremendous quantity of heat which is transferred to the earth from the sun by radiation. And if we are of an inquiring turn of mind, we can, by means of a simple experiment, learn something about radiant energy.

With an ordinary magnifying glass lens, we can focus the rays of the sun on a piece of paper. We will see a curl of smoke and the paper will burst into flame, ignited by the heat radiated from the sun.

From this it is easy to deduce that heat and light obey the same laws, and that radiant heat, as does light, travels in a straight line. Verification for this is found in the fact that if we expose our bodies to the rays of the sun for a sufficient length of time our skin will become burned, but if we stand in the shade where the sun's rays do not strike us, we will suffer no ill effects.

In studying the energy radiated from a hot body, scientists use an instrument called the spectroscope, which disperses the rays of energy into a multi-colored band or spectrum according to the length of the waves. Thus the color we know as red is merely an energy wave of different length than the wave that registers through our sense of sight as blue. White is a combination of all visible waves or colors.

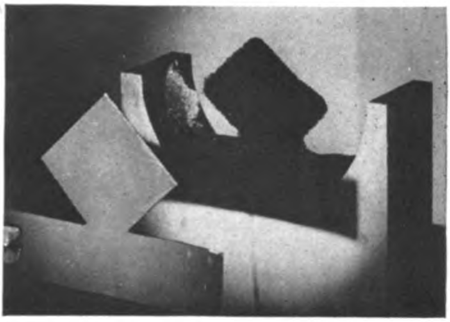
Only a small group of these energy waves, however, affect the human eye, and these are known as light. The waves of greater length than red are called infra-red, or heat waves. They can be detected only with the use of heat measuring devices. The greatest portion of the energy radiated from hot bodies is in the form of these infra-red rays.

Shorter Rays of the Spectrum

Energy rays of wave lengths shorter than light rays are known as ultra-violet, X-rays, etc. These will affect a photographic plate.

Heat and light rays travel at the same rate of speed which is approximately 186,300 miles per second. Only eight minutes are required for the life-giving heat and light rays of the sun to reach the earth from the tremendous distance of 93 million miles.

The great difficulty in understanding the movement of these heat and light rays, lies in the fact that they need no material medium to assist in the transfer, as witness the heat and light radiated to the earth by the sun.



Heat rays travel in a straight line as can be proved by this test shown above. The rays of a powerful arc lamp were directed upon a block of ice, painted black. The portion of the ice which was shadowed by the screen did not melt.

There are, however, materials that will not allow heat rays to pass at all, while allowing light rays to pass freely. Conversely, there are materials which allow radiant energy, or infra-red rays, as they are called, to pass while shutting out all visible, or light rays.

The ability of any body to radiate heat depends largely on its surface. Bodies with smooth, shiny surfaces such as polished chrome plate, for instance, are excellent reflectors but very poor radiators of heat. On the other hand, bodies possessing dull, comparatively rough surfaces usually have a marked ability to radiate heat.

Heat Transfer in a Boiler

An excellent illustration of just how industry uses the three methods of heat transfer that we have discussed here, is found in the making of steam in a boiler.

Here, available energy, in the form of coal, oil or gas, is transformed into heat energy through combustion. The heat energy passes to the boiler tubes by radiation and convection; and through the tube walls by conduction. The water in the tubes transmits the heat by convection.

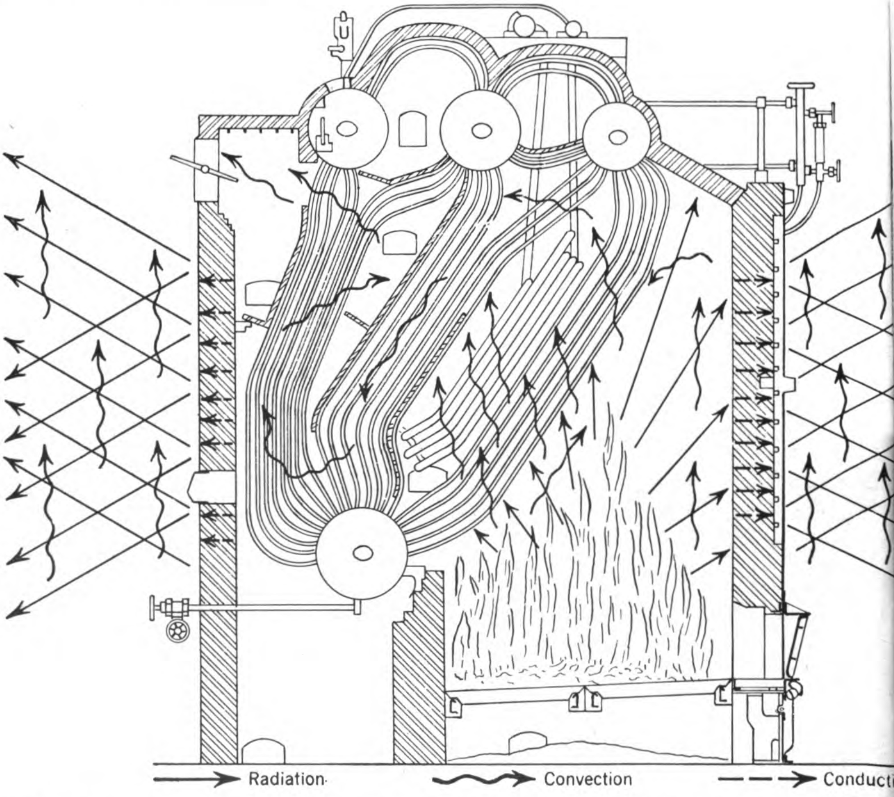
If the boiler is not properly insulated so as to conserve as much heat as possible, a great deal of heat loss results from radiation and convection to the boiler wall; conduction through the wall; and radiation and convection outside the wall.

The rate at which heat is transmitted by conduction through the wall varies *directly* with the area of the wall, the temperature difference between the hot and cold surfaces of the wall, the thermal conductivity of the materials of which the wall is composed and *inversely* with the thickness of the wall.

By the application of scientifically signed insulating materials, we may duce the heat loss through the boiler to a minimum, thus conserving avail energy to do useful work, and at same time lowering operating costs.

But, what are scientifically desi insulating materials? How do we k such materials will conserve heat? if so, will the resultant savings in cost justify the expense of insulation

The answers to these questions li what science is today accomplishing the art of heat conservation thro insulation.



Heat is transferred in a boiler by radiation, conduction and convection, as shown by the three types arrows in this illustration. If the boiler is not properly insulated a great deal of heat is lost through rad tion and convection to the wall, conduction through the wall, and radiation and convection outside of the wa

hree views of quipment sed in Johns-anville Labo-tories to Test onductivity

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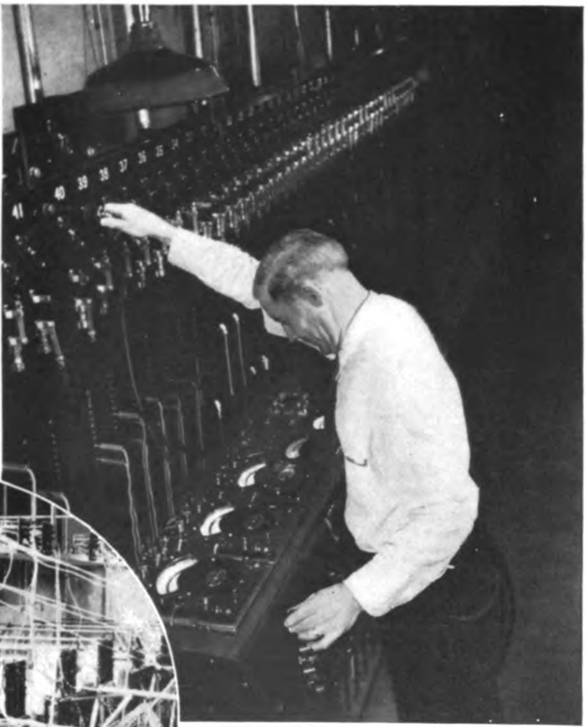
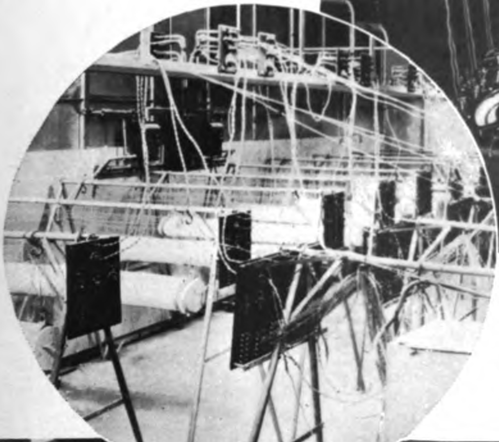
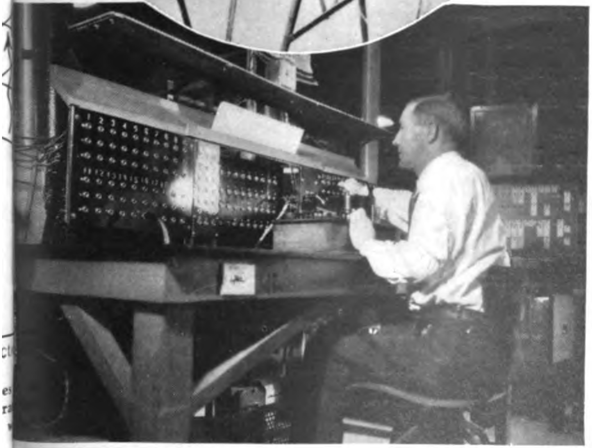


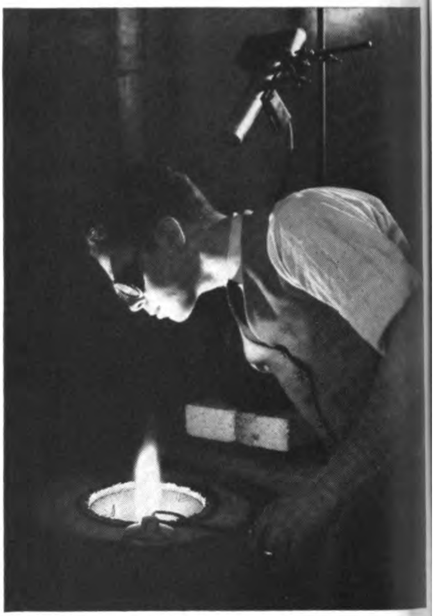
From the switchboard shown above electrical power is supplied to the heaters in various conductivity testing units of the J-M Insulation Laboratories. Power input to any heater may be measured to within ½ of 1 per cent.





One of the testing units is shown in the circle to the left. In this constant temperature room pipe insulation is tested for thermal efficiency by being applied to a six-foot section of electrically heated pipe. Switches and thermocouple and power wires aid the test, the thermocouple wires being connected with the central thermocouple "jack" switchboard shown at the left below. Here, with the aid of a single precision potentiometer, temperatures are measured to within ⅓ of 1 deg. F. Temperatures may be measured at approximately 800 different points.

Guardians of the B. t. u.



A scene from the Johns-Manville Research Labora-tories where "Guardians of the B. t. u." are on con-stant vigil in their efforts to control heat. That is not flame coming from this Ajax-Northrup electric induction furnace. It is white heat. The furnace was at 3200° F. when the photo was taken.

DURING the decade ending in 1860, when the conservation of energy theory propounded by Mayer, Helmholtz and Joule was becoming widely established as fact, another important page in the history of man's mastery over heat was being written in Brooklyn, New York. There, in 1858, the first step toward the development of materials specifically designed for insulation and reduction of heat loss was made by H. W. Johns, who recognized the possibilities in this field.

It was in Mr. Johns' modest factory where some of our earliest asbestos insulations were made, crude products in cement form which were sold, with considerable difficulty, to the more progressive industrial plants of the day for covering boilers and steam pipes.

This was twenty years before Edison built the first electric light plant, and long before industry became generally concerned with the problem of fuel conservation and with the more efficient utilization of heat.

Today, to aid industry in solving its problems of conserving heat, Johns-Manville operates, in its Manville, N. J. plant as a section of the Johns-Manville Research Laboratories, one of the best equipped, and most modern heat insulation laboratories in the world.

It is here that a large staff of engineer chemists, physicists and other special trained technicians devote their entir time and energy to the advancement o the art and science of heat control.

Known as the McMillan Laborator this J-M laboratory was named for it founder, the late L. B. McMillan, wh as instructor at the University of Wis consin, established himself as the leadin American authority on industrial insula tion by conducting in 1915 the first com prehensive thermal conductivity tests eve made of all commercial pipe insulation then on the market.

Accurate Conductivity Measurements

The conductivity of a material, course, is the factor which determines i insulating efficiency, and therefore, great deal of care must be exercised measure this conductivity with a hig degree of accuracy. Years of specializ training are required to equip a man for this task. Special test apparatus of various types, including precise electrical equipment, is also necessary.

It is here that perhaps the most significant contributions of Johns-Manville laboratory research men have been made in the field of insulation. For in these laboratories some of the most difficult problems connected with the measurement of heat transfer have been solved.

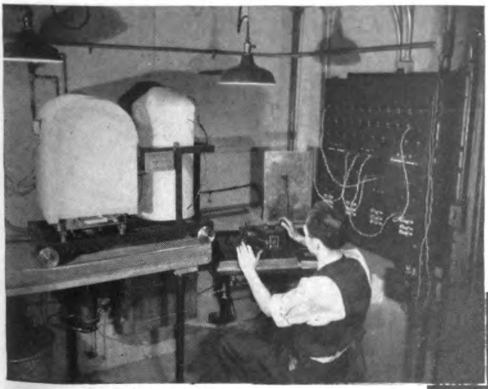
The difficulty in measuring thermal conductivity lies in the fact that unlike electricity, which may be confined to the desired channel, it is extremely difficult to direct the flow of heat, and thus limit losses, due to convection, conduction and radiation, to the test sample whose conductivity is being measured.

Additional obstacles to accurate measurements are encountered due to the misbehavior under high temperature of ordinary materials of apparatus construction; the warping, crystallizing or scaling of metals; and the softening or burning of electrical insulators, which then become good electrical conductors.

In spite of these difficulties, however, accurate thermal conductivities can now be measured in the J-M laboratory from zero degrees Fahrenheit to the intense heat of 2600 degrees above.

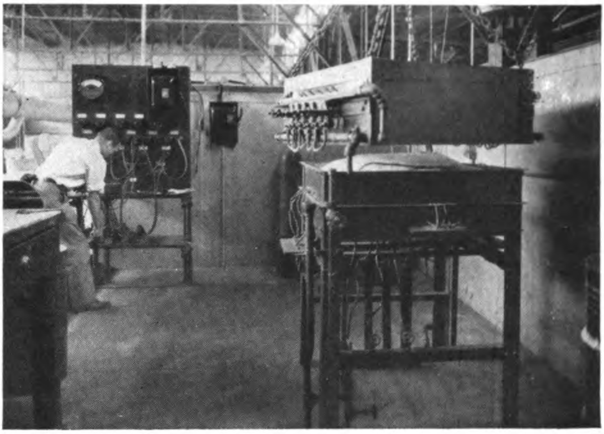
The Thermocouple

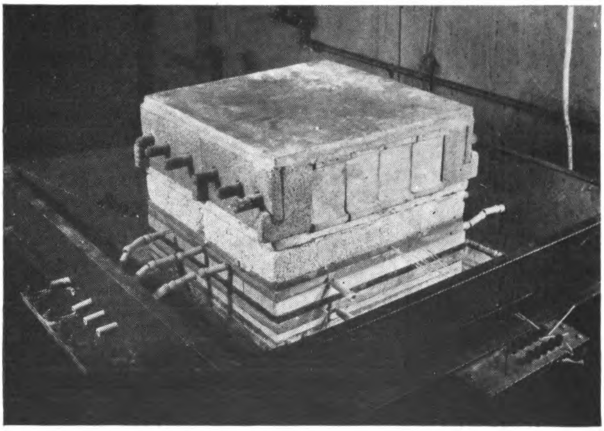
As a sensitive and at the same time practical device for the measurement of temperature in the determining of thermal conductivities, scientists have developed the thermocouple. Two wires of dissimilar metals are welded end to end to form a circuit. Then, one of these wires is cut to make a place for a potentiometer which, when attached, becomes a part of the circuit. One of the welded ends, or junctions, is placed at a point where temperature is to be measured, the other kept at a constant temperature in an ice-water bath. The difference in temperature between the hot and cold junctions sets up electromotive forces which are measured by the potentiometer. This device is one of the most sensitive and accurate known for measuring temperature over a wide range.



Left: **Heat mirrors under test. For a complete understanding of insulating materials, consideration must be given to the "thermal reflectivity" of the products. A recent J-M laboratory development has been construction of this "heat eye" which measures surface emissivity.**

Right: **A completed assembly for test on thermal conductivity of high temperature insulating material. Photo shows operator filling an improved, self controlled conductivity unit with insulating powder.**





The apparatus shown in these two illustrations was designed and constructed in the Johns-Manville Research Laboratories to meet the special requirements of high temperature conductivity measurements in the range of temperatures from 2000° to 2600° F. *Top:* The general assembly of the apparatus with the power control switchboard in the background. *Bottom:* A typical assembly for the testing of insulating brick.

Under high temperatures, only the noble metals will stand up, and the J-M laboratory uses as thermocouples hundreds of feet of wire made up of pure platinum and platinum-rhodium. For the temperature range up to 600° F., thousands of feet of electrolytically pure copper and a uniform composition copper-nickel alloy are used.

Tests on the conductivity of medium temperature pipe insulation are conducted in a special room in the Johns-Manville Laboratories which is kept at a constant temperature at all times. The insulations under test are applied to pipes containing electric heater units. The thermal conductivity of a material is evaluated by computing the amount of electrical energy necessary to compensate for the heat loss through a section of insulation. This is calculated on the basis of unit area, unit thickness and unit temperature difference.

The electrical energy—or heat—is supplied from a central switchboard located in the control room of the laboratories. From this switchboard, which runs the entire length of the room, the electrical power input to any test unit, no matter where located in the laboratories, can be regulated accurately by a group of watt meters mounted on a movable carriage.

In addition to the room for testing medium-temperature pipe insulations, there is a "cold" room for testing materials used in refrigerating service. In this room temperatures may be automatically regulated and kept constant at any point down to zero degrees Fahrenheit.

The same procedure used in testing medium temperature pipe covering is used in the cold room for testing low temperature pipe insulation. Although in service the insulation is designed to keep heat from the refrigerant in the pipe, in the laboratory the use of heaters inside the insulation provides more accurate results than could be obtained by the application of heat to the outside of the insulation.

For the testing of flat materials the Bureau of Standards type conductivity apparatus is used. Here heat is developed electrically in guarded heater plates, and flows equally through test samples placed on either side of the plate, and is then absorbed by two water-cooled plates which are clamped to the outer surfaces of the materials under test. Temperatures are taken with the use of thermocouples located in the surfaces of center and guard areas of the heater plates as well as surfaces of the cold plates.

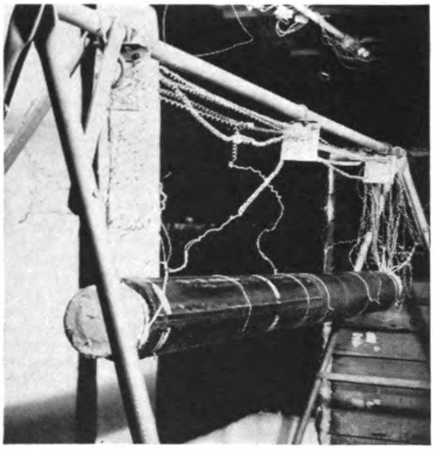
High Temperature Tests

Some of the most notable achievements of the Johns-Manville Research Laboratories have been made in the field of testing high temperature insulations. It was in these Laboratories, for example, that the scope of accurate thermal conductivity measurements was increased from about 2000° to 2600° F.

This testing of insulating materials used in industrial furnaces at temperatures ranging up to 2600° F. presents many difficulties. In order to obtain accurate results it is necessary to use heater plates constructed of a refractory material and high-temperature alloy wires; thermocouples of platinum and platinum-rhodium; and supplementary heater plates on the cooler surfaces of test samples.

It is not enough to make a few tests to prove two or three isolated qualities of an insulating material. True, thermal conductivity is the corner stone, but a thorough research job subjects the material to every conceivable condition which it will be called upon to face in actual service and extends even to the building of furnaces and the providing of other special facilities where field conditions may be simulated.

In addition to high insulating efficiency, one of the most important properties an insulating material should possess is strength. The transverse strength is a criterion of its ability to withstand damage from handling and shipping. Tests on compressive strength, conducted while the test specimens are heated to high temperatures, give a direct indication of load bearing ability under actual service conditions.



An interior view of the "cold room" in which insulations for service in the low temperature range are tested. The temperature in this room can be automatically regulated and kept constant down to zero degrees F.

The expansion of insulating materials when subjected to heat must also be determined. If not accurately evaluated, and proper allowance made, expansion of the insulating brick and block may cause serious damage when a high temperature furnace is placed in operation.

Many insulating materials are destroyed by thermal shock and a spalling test must be conducted to determine the ability of a material to withstand rapid heating and cooling.

In order to determine the behavior of materials under extremely severe conditions a Navy type test furnace is used. It was originally designed for the testing of high temperature, semi-refractory insulating brick for use in navy boilers. It has since found a much wider use. If a material will retain its stability under this test, there is little, if any, chance of its failing in industrial furnaces.

Additional Tests

Insulation for use outdoors must be protected from the elements, so the laboratory reproduces sunshine, rain and freezing in cycles, for the accelerated testing of weather-proof jackets and casings.

Because the leakage of hot gases or cold air through furnace walls often proves costly to industry, materials designed for furnace insulation must be tested for their ability to resist the flow of air.

This characteristic, known as the permeability of a material, is measured by placing the test sample in a specially designed apparatus where all sides of the material are sealed against gas leaks by mercury. A given pressure difference is maintained between the top and the bottom of the specimen and the rate at which gas passes through it is accurately measured.

Needless to say, in the short space of this story no attempt can be made to describe all of the various tests in detail. Months, even years, are required to build up enough data on the ability of a certain insulation to withstand all of the conditions that it will encounter in service.

Since the time of its founding in 1917, the present Johns-Manville Insulation Laboratory has established a vast fund of invaluable data on the true nature, structure and properties of insulating materials.

To gain an idea of the scope and variety of the work involved in insulation research, it is only necessary to consider the many different types of insulating products in use today, and to realize that here is an ever-changing field in which industrial progress, in a few short years, changes the entire complexion of problems to be faced.

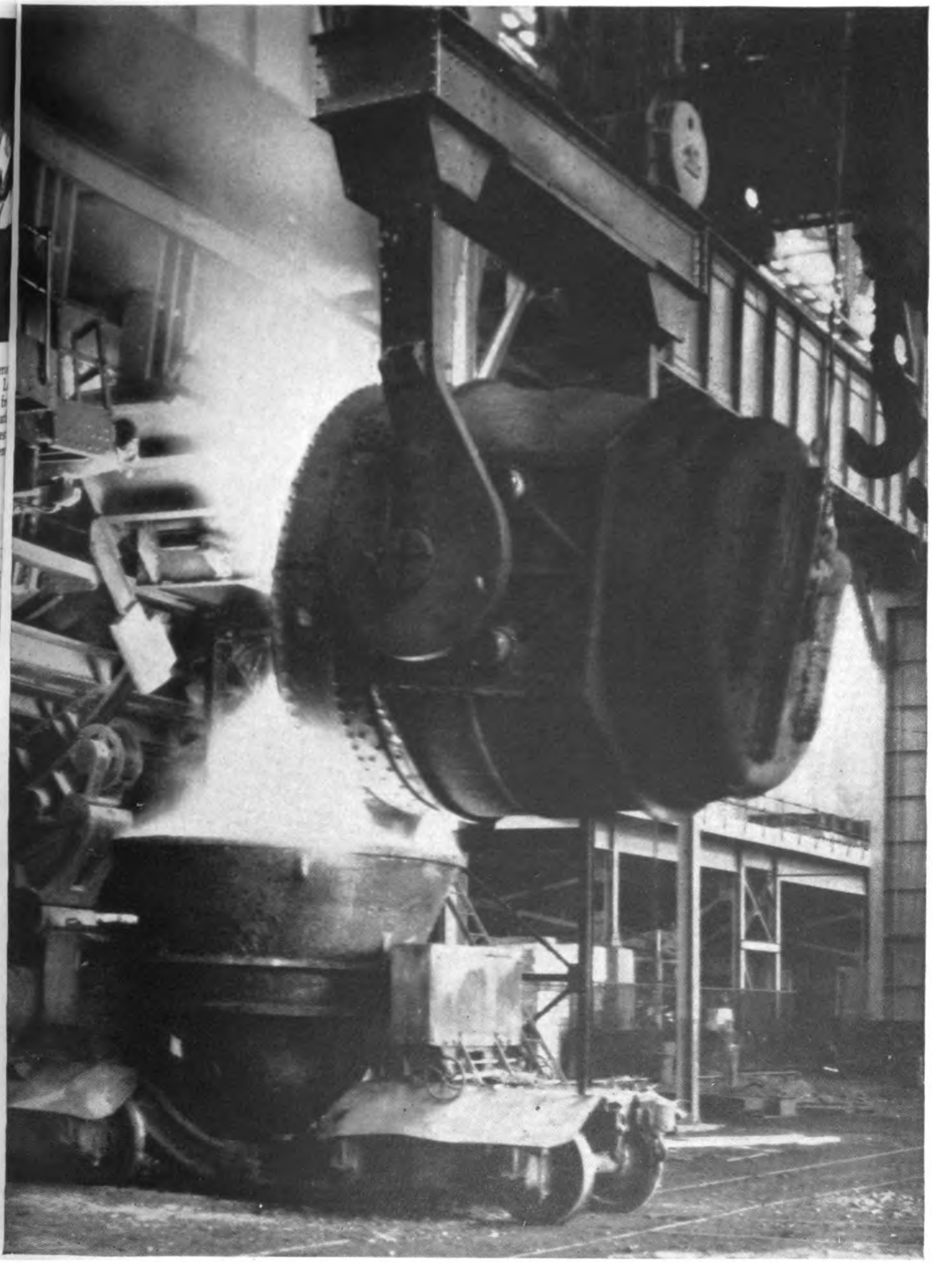
Inspecting samples of material in the Weatheromete a machine in the Johns-Manville Research Labor tories which reproduces sunshine, rain, and freezin temperatures in cycles for the accelerated weatherin of insulation jackets and casings in order to test thei ability to withstand exposure to the elements.

It is, of course, necessary that these research men keep in close touch with the problems of industry, and any new developments that might arise that would necessitate new or improved types of insulation.

The Insulation Engineer

To provide this link between industry and the research laboratories, Johns-Manville maintains a staff of insulation engineers who specialize in assisting industry in solving its heat conservation problems. These men, using the data supplied them by the J-M Research Laboratories, render invaluable aid to users of fuel by recommending both the type of insulation best suited for any specific job, as well as the most economical thickness.

Experts in their own right, these insulation engineers are free to request the assistance and entire resources of the Research Laboratories in solving any particular problem which, because of its unusualness, might require special consideration. In turn, they provide the Research Laboratories with vital information concerning the changing needs of industry.



A Steel Mill Open Hearth . . .

Wherever heat or refrigeration is used in industry there also will be found insulations, helping to cut production costs and create better, more uniform products by assuring more accurate temperature control.

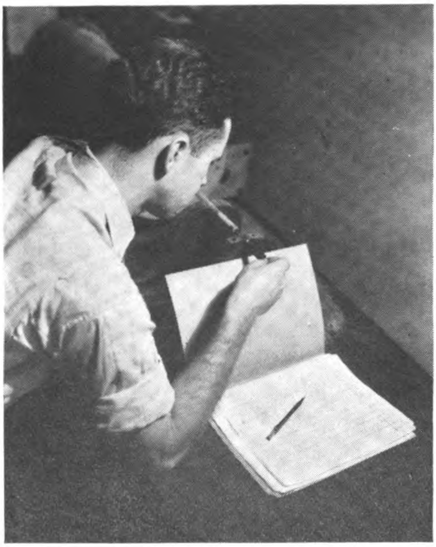
INSULATIONS...

Barriers to Industrial Waste

NO one or two types of material can be expected to serve under the wide variety of conditions insulation is called upon to meet today.

For example, the temperature may be below zero or up to 3000° F. The surface to be insulated may be a pipe, a tank, or a furnace floor, wall, roof, or door. The surface may be regular in contour, or broken up with projecting fittings or accessories. The insulation may be indoors or outdoors. It may be subjected to abuse, or to severe vibration or mechanical abrasion.

Of course this was not always true. Insulation was once that "white stuff" wrapped around pipes, daubed on boilers. But industrial progress gradually brought new conditions, necessitating an ever-widening variety of kinds and forms of insulation to help assure the low production costs that soon became the vital concern of every type of industry.



A split hair at furnace heat! Measuring with a micrometer gauge the thermal changes of a high temperature insulation material. Furnace at left containing test specimen is accurately controlled. Expansion or contraction at high temperatures must be fully understood before recommendations for specific installations are given.

During the past three-quarters of a century, research, development, and manufacture of insulation have been carried on by Johns-Manville with the result that today, from four basic materials, a great number of insulating products are manufactured to provide the proper type and form for every insulation requirement.

From these four basic materials—asbestos, magnesium carbonate, diatomaceous silica (Celite), and rock or mineral wool — Johns-Manville produces insulation in the forms of sectional pipe covering; insulating sheets, blocks, bricks and blankets; insulating cements, fillers and finishes; insulating papers and felts; as well as a lightweight aggregate used with portland cement for making insulating concrete. A wide range of hair felt products completes the line.

Insulation for All Temperatures

These materials provide insulations for use throughout the entire range of temperatures met with in industrial processes, from the extreme sub-zero temperatures used in the treatment of oils, chemicals and the like, to temperatures of 3000° F., and more, in many modern industrial plants.

Many of these materials are suitable for service in the lower temperature ranges. Among the more important of these insulations are rock cork and hair felt for refrigeration and other low temperature service; and asbestos, 85% magnesia and rock wool for medium temperatures ranging up to 1000° F.

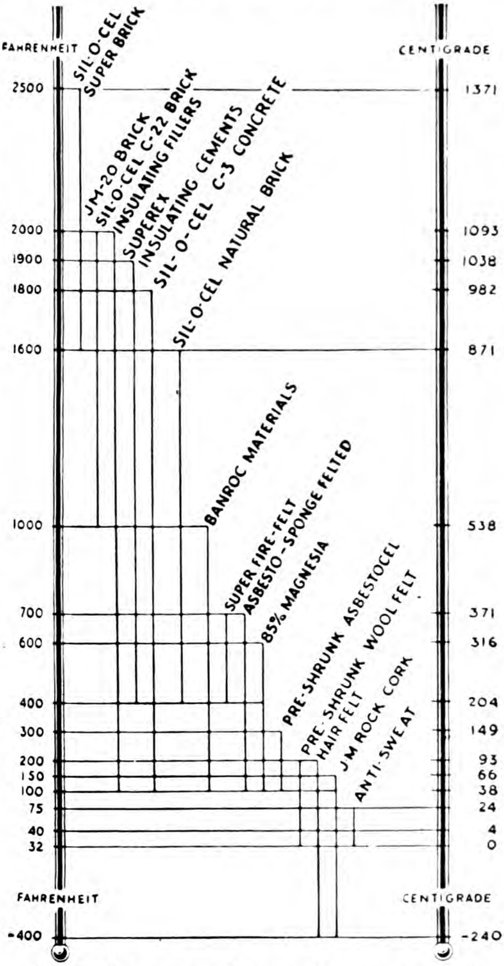
These materials possess exceptionally

low thermal conductivities, as well as the other qualities necessary to make them applicable in their fields, such as strength, durability and moisture resistance.

For high temperature service, however, to be of value an insulating material must not only have a low conductivity, but also a high degree of refractoriness, a quality not ordinarily found in insulating materials. Up until less than thirty years ago, there was no material available that possessed sufficient refractoriness to be of use in the higher temperature ranges.

At that time, with no suitable insulation available, the loss of valuable heat used in certain processes in manufacturing steel and metal products, glass, portland cement and lime, brick, tile and pottery, was tremendous.

Attempts were made to curtail this loss by building furnace walls of brick several feet thick, but this method was unsatisfactory because construction costs were exceedingly high, and such walls soaked up heat like a sponge, thus robbing the furnace of heat.



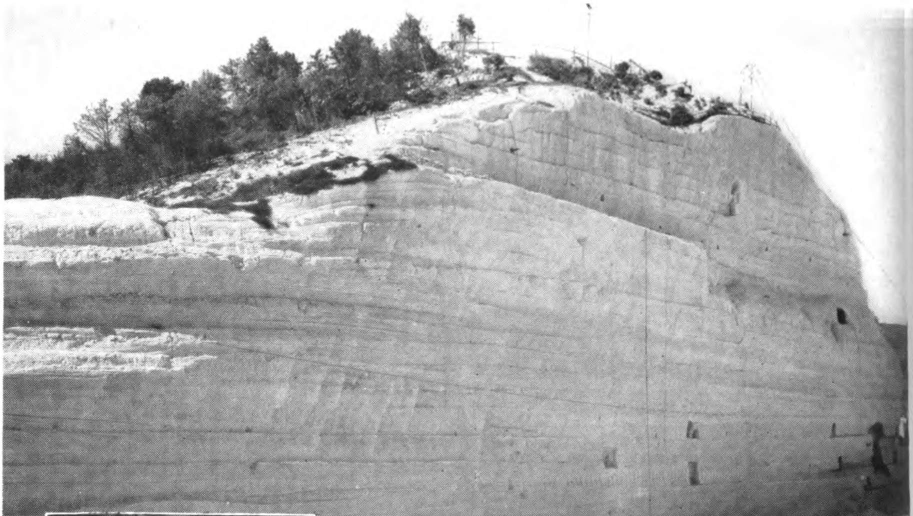
J-M Insulating materials cover the entire range of industrial temperatures.

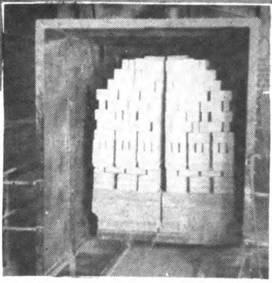
Diatomaceous Silica

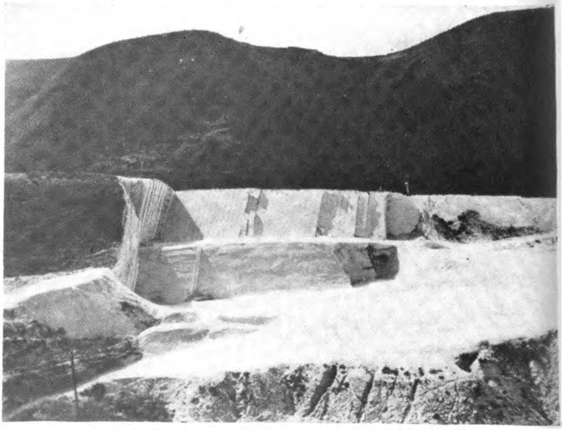
In 1912, a new insulation was put on the market. Composed of diatomaceous silica, it made available, for the first time, an insulation suitable for use at high temperatures. This new material not only effected enormous fuel savings, and lower production costs wherever it was used, but it also made possible closer control of temperatures and more even distribution of heat in the furnace, with the result that better quality products could be produced.

The story of this material and the later high temperature insulations that were developed from it, begins with the death millions of years ago of a microscopic plant called a "diatom," which lived in the rolling waters that swept over what is now California.

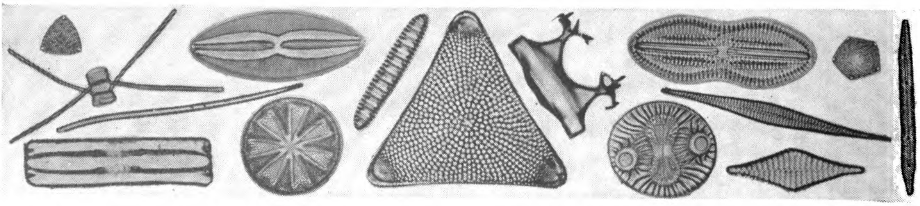
Upon its death this minute organism sank to the ocean floor, leaving as its only trace a silica shell built up during its life. Countless billions of other diatoms lived and died in these same waters and their tiny skeletons piled up in layer after layer, during some thirty thousand years, to form huge deposits of almost pure silica more than 1400 feet in thickness.







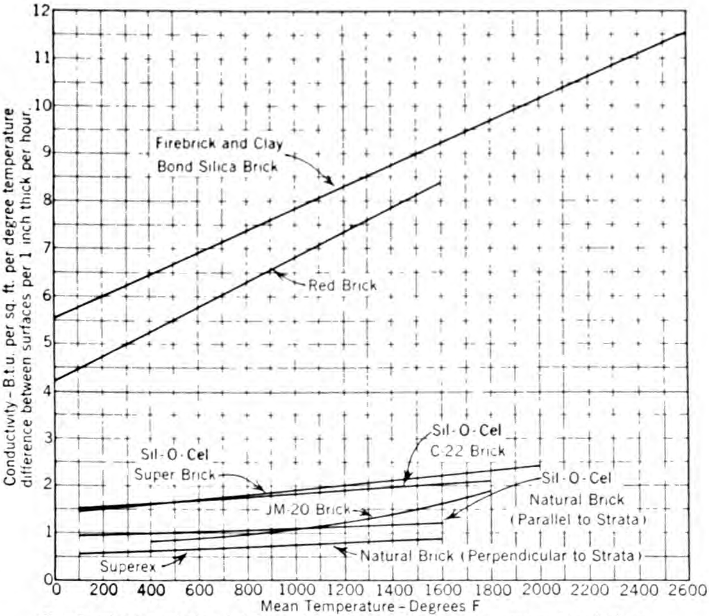
Top: The largest and purest source of diatomaceous silica is the Johns-Manville quarries at Lompoc, California, a small section of which is shown here. *Above:* Diatomaceous silica (Celite) after being ground, pugged and pressed is fired in kilns to produce Sil-O-Cel C-22 and Sil-O-Cel Super Brick. *Right:* Another of the J-M diatomaceous silica quarries at Lompoc, California.



Above: A representative group of diatoms from the Lompoc deposit. These tiny skeletons of minute marine organisms which lived and died millions of years ago are so small that they can be seen only with the aid of a powerful microscope.

In these deposits f diatomaceous arth, or Celite, hrust above sea level y the continental ise, and now comprising the hills in he vicinity of Lompoc, California, Nature has provided one of the most efficient high temperature insulating materials yet discovered.

Because Celite is virtually pure silica, it has an unusually high melting point—2930° F., and its unique physical structure is responsible for its remarkable insulating efficiency.



Conductivities of fire brick, red brick and high temperature insulating materials.

Sil-O-Cel Natural Brick

The skeleton of an individual diatom is in the form of a cell so small that 50 million of them could be placed in a penny match-box without crowding. Sil-O-Cel Natural Brick, or brick cut from the pure Celite, contain myriads of tiny voids formed by these minute diatom skeletons. These voids represent as much as 85 percent of the volume of the brick, and thus loss of heat by conduction is reduced to a minimum because of the small proportion of solid material present.

Heat, of course, is transferred across pore spaces by convection and radiation, but since the voids in Sil-O-Cel Natural Brick are so microscopically small, a tremendous number of surfaces are interposed in the path of heat flow, and thus heat losses due to internal radiation and convection within the material also are reduced to a minimum.

Sil-O-Cel Natural Brick will retain its high insulating efficiency indefinitely in service where it is subjected to temperatures up to 1600° F. behind refractory linings.

Other Sil-O-Cel Brick

In manufacturing insulating brick for use in equipment operated at higher temperatures, the pure Celite is ground, pugged, pressed and fired in kilns to produce Sil-O-Cel C-22 Brick, which can be subjected to service temperatures up to 2000° F., and Sil-O-Cel Super Brick for use where the insulation will encounter temperatures as high as 2500° F. This processing results in brick having a considerably higher degree of refractoriness.

This added heat resistance allows Sil-O-Cel C-22 Brick, in addition to their wide use as a back-up insulation to refractory linings in furnaces operating at very high temperatures, also to be used as a direct refractory lining to replace fire brick in oil and gas-fired furnaces, electric furnaces of the resistance type, and coal-fired furnaces where not subjected to mechanical abrasion or slag action.

Using the material in this manner, as a combination refractory and insulation, not only results in a saving in construction costs, but also cuts down the heat storage capacity of the masonry, thus saving heat to do effective work.

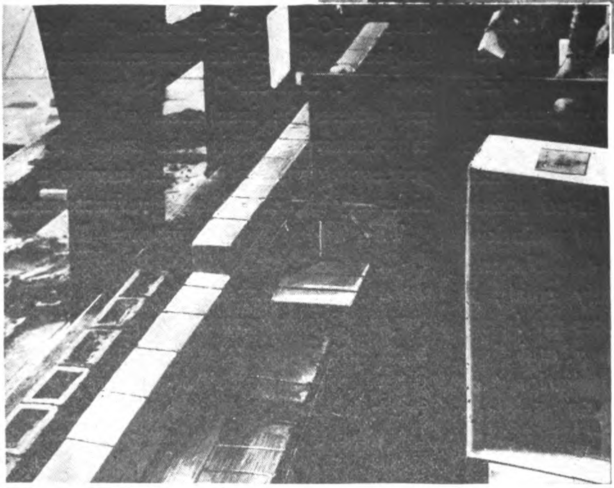
Since C-22 Brick have a heat capacity less than one-third that of fire brick, savings in both fuel and heating up time can be made in intermittently operated furnaces due to the lower amount of heat absorbed by the walls. In preventing transmitted heat loss due to conduction, Sil-O-Cel C-22 Brick are three to four times as effective as fire brick due to their high porosity and small air cells.

Sil-O-Cel Super Brick are designed for exceptionally high temperature conditions. They are used where subjected to temperatures up to 2500° F., behind refractory linings.

In addition to the Sil-O-Cel Bricks there is another type of material for insulating high temperature furnaces known as JM-20 Insulating Brick.

JM-20 Insulating Brick

JM-20 Brick are composed of a high quality refractory clay and a specially manufactured mineral fibre. They have unusually low conductivity, light weight, and at the same time, high heat resistance, which makes them suitable for use at temperatures up to 2000° F., in back of fire brick or insulating fire brick in annealing furnaces, heat treating furnaces, enameling furnaces, regenerators, galvanizing furnaces, soaking pits and other similar types of heated industrial equipment. JM-20 Brick are also recommended for use as an insulating refractory in electric furnaces, glass lehrs, radiant tube



Above: **One of six malleable annealing furnaces in the Canton Malleable Iron Company, Canton, Ohio. In these furnaces Sil-O-Cel C-22 Brick is used as a combination insulation and refractory lining for walls, roofs and doors. For the past six years C-22 Brick has saved enough fuel to pay over 100 per cent annual return on its cost, and is still in perfect condition. *Left:* Here Sil-O-Cel C-22 Brick is used in "core wall" construction behind the fire brick lining in the furnace wall of an oil-cracking unit.**

Right: These large japanning ovens at Durand Steel Locker Company, Chicago Heights, Illinois, were built entirely of Sil-O-Cel C-3 Concrete. *Below:* The C-3 Concrete doors on this battery of malleable annealing ovens are nine inches thick. They weigh only half as much as fire brick and conduct one-third as much heat, thus saving fuel as well as improving furnace performance and working conditions.

annealing furnaces, muffle type furnaces, etc., where there is no flame impingement, slag action or mechanical abrasion.

It is ordinarily preferable to use insulation in the form of bricks, blocks or pipe sections, but there are times when conditions render the use of such solid insulations impossible. In such cases, insulating cement, insulating concrete, or fill types of insulation may be used.

Insulating Concrete

The most widely used insulating concrete is Sil-O-Cel C-3, a semi-refractory, monolithic type of insulation made by mixing four parts of Sil-O-Cel C-3—a calcined granular form of Celite—with one part of portland or Lumnite cement, by volume, and sufficient water to form a plastic, coherent mass. The development of this material, about 20 years ago, first made possible the lining of industrial furnace doors with an insulating material. Today there are thousands of these C-3 insulated doors on furnaces of many different types.

Sil-O-Cel C-3 Concrete is over three times as effective as fire clay brick in reducing heat transfer. It has a high degree of refractoriness and can be used without other refractory protection where it may be subjected to direct heat as high as 1800° F. Sil-O-Cel C-3 Concrete weighs less than half as much as fire brick.

It is also an ideal material for insulating the bases of various types of heat-treating furnaces, kilns, oil still furnaces, hot blast stoves, open hearth furnace regenerators and flues, and many other types of high temperature equipment. Insulating the bases of such equipment not only saves fuel but also insures more uniform heat distribution within the equipment and protects the foundation from excessive heat.

Sil-O-Cel C-3 Concrete is also used

for making up special shapes of various kinds; for the construction of fire screens to protect men working in front of open furnace doors; and for a great variety of other uses.

The Sil-O-Cel C-3 granules used in making C-3 Concrete, are also widely used as an insulation fill at temperatures up to 2000° F.

Sil-O-Cel Coarse Grade is coarsely ground Celite for use as an insulating filler up to 1600° F., while Sil-O-Cel Insulating Powder is a finely ground Celite for the same purpose.

Fibro-Cel is a mixture of Celite and long fibre asbestos. Because it does not settle under vibration or sift through cracks, it is well adapted for use as a fill insulation between the fire brick wall and steel shell of generator sets in the gas industry. Fibro-Cel can be used for temperatures up to 1800° F.

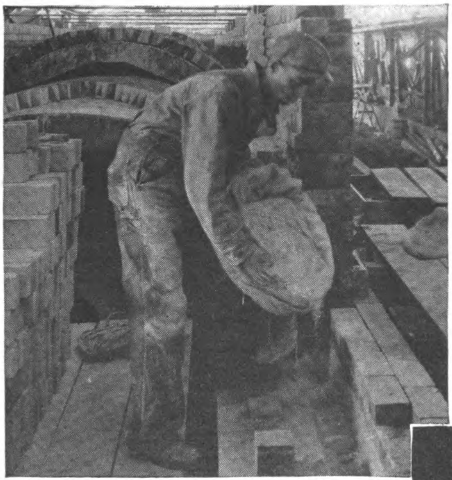
Natural Celite, used in producing these fills, as well as the Sil-O-Cel bricks previously mentioned, can only be prepared in brick or powder form, and therefore, in order to extend its range of usefulness, it is necessary to combine it with other materials, such as asbestos.

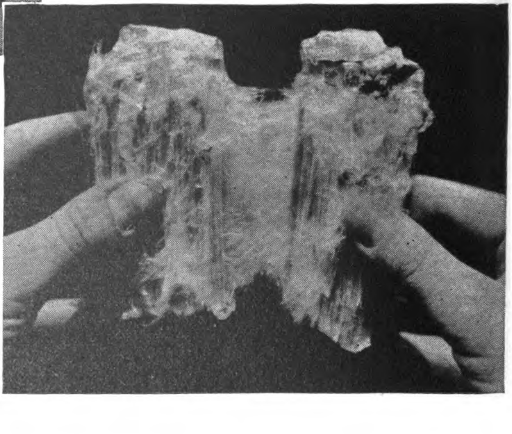
Asbestos

Asbestos, often called the "magic" mineral, is one of Nature's most amazing materials. Dense and rock-like in its original form, it can be crushed and fluffed into soft, silky fibres. Historical legend tells us that Charlemagne, or Charles the Great, averted a war with Harun-Al-Rashid, Emperor of the East, by having a tablecloth woven out of asbestos fibres, and "cleansing" it with fire before the startled eyes of the Moslem's envoys. Awed by this display, their report dampened the Emperor's enthusiasm for a war with so potent a magician.

Superex Insulation

Today, one of the many uses for asbestos in the field of insulation is in the making of Superex Blocks and Pipe Insulation. Carefully selected and calcined Celite is blended and bonded with asbestos fibres, whose inherent strength and per-





Above: **Workman installing Sil-O-Cel Coarse Grade in the wall of Harrop Tunnel Kiln at A. P. Green Fire Brick Company, Mexico, Missouri. Sil-O-Cel Coarse Grade is also used on the top.** ***Right:*** **Asbestos, often called the "magic" mineral, is dense and rock-like in its original form, yet it can be crushed and fluffed into soft, silky fibres.**

ence due to their mineral composi- give the combination of Celite and stos the qualities necessary to allow molding into blocks and pipe insula- of any desired size and thickness.

uperex, safely withstanding tempera- es up to 1900° F., is generally recog- ed as the outstanding material in block m for insulating the high temperature ipment used in steel and cement mills, refineries, and glass, power and other lustrial plants that employ high tem- ratures in manufacturing.

The high insulating value of Superex rmits a minimum thickness to be used, sulting in savings, not only in the cost f insulation, but also, in many cases, dditional savings in furnace construc- ion costs. Installation labor costs are also kept to a minimum because the blocks are large.

In the form of pipe insulation, Superex is used to insulate the high-temperature steam lines now found in modern public utility and industrial power plants. In such service it is usually applied in combination with other materials.

In the moderate temperature range, the basic quality of an efficient insulation—low thermal conductivity—is still of paramount importance, but the high degree of refractoriness so necessary in the higher temperature ranges is not at all essential.

85% Magnesia Insulation

The standard insulation in this field for many years, due to its qualities of economy and efficiency, has been a combination of asbestos fibre and magnesium carbonate, known as 85% Magnesia.

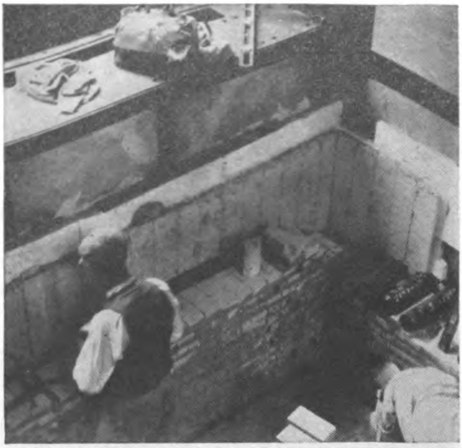
The raw material used in producing this insulation is dolomite limestone, which, through a series of chemical processes, is transformed into magnesium carbonate. Dolomite which has a relatively high thermal conductivity approximating twice that of portland cement concrete, becomes twenty-five to thirty times more effective in resisting the passage of heat when converted into 85% magnesia insulation.

This tremendous reduction in thermal conductivity is brought about by chemical processes which increase the pore space content of the material to 90 per cent of the total volume. These processes include calcination of the dolomite, slaking in water, the addition of carbon dioxide to eliminate calcium carbonate, and precipitation of the magnesium carbonate.

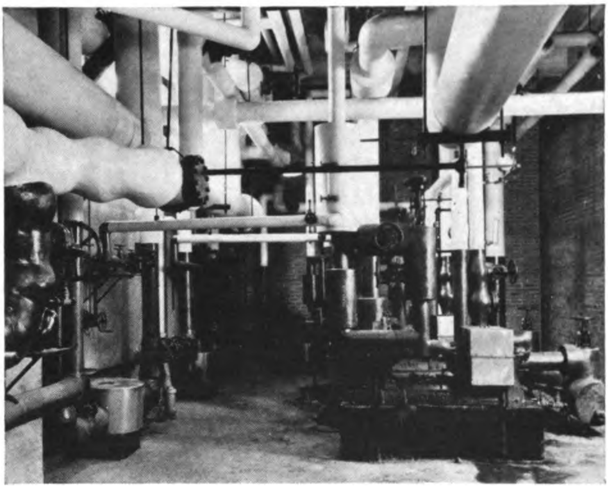
Following precipitation, the magnesium carbonate is mixed with approximately 15 per cent asbestos fibre, which as it does in the case of Superex, provides the necessary bonding and reinforcing qualities to allow molding the material into blocks, pipe sections and lagging.

J-M 85% Magnesia is the most widely used insulation for steam lines operating at temperatures up to 600° F. Thousands of installations made over a period of many years have shown that it is remarkably effective in maintaining its high insulating efficiency over long periods of time — an important factor in determining the economy of the installation.

In block form, J-M 85% Magnesia is



The furnace of an oil-cracking unit being insulated with Superex Combination Insulation, consisting of Superex Block next to the fire brick followed by a layer of J-M 85% Magnesia.



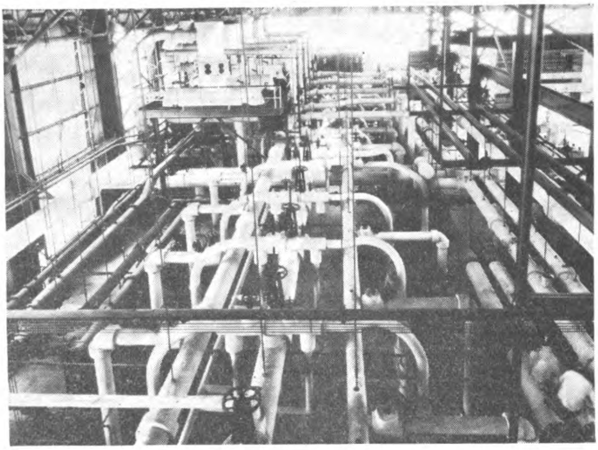
Johns-Manville 85% Magnesia Pipe Insulation installed on the steam lines in the power plant of the Elmira, N. Y., State Penitentiary.

just as efficient and economical for insulating boiler drums, breechings and ducts, heated tanks, steam locomotives and many other types of equipment. Today it is probably safe to say that there is scarcely an industrial or power plant in the entire country, in which 85% Magnesia insulation is not used.

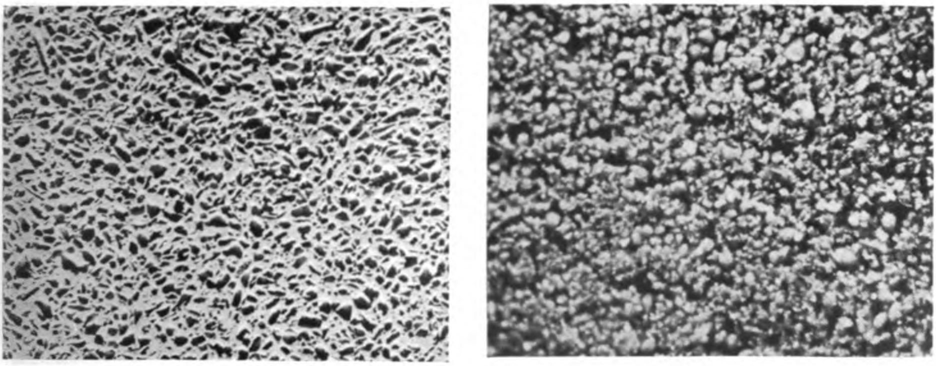
The field of usefulness for J-M 85% Magnesia is greatly broadened by its combination with Superex Blocks and Pipe Insulation to insulate furnace walls, heated surfaces and steam lines where the insulation must withstand temperatures exceeding 600° F. In this method of insulating a first or inner layer of Superex is covered by a layer of J-M 85% Magnesia. The Superex is used as protection for the 85% Magnesia, which, although high in insulating value, is lower in heat resistance than Superex.

Other Asbestos Insulations

Asbestos is the basic material used in fabricating a number of other types of insulation. The most important of these is built up of felts composed of asbestos and small particles of spongy, cellular material. Known as Asbesto-Sponge Felted, and produced in sheet, block or pipe insulation form, this material is a remarkably efficient insulation due to the great amount of entrapped dead air and the many surfaces interposed in the path of heat flow. The tightly laminated construction of tough asbestos felts—about 40 laminations per inch of thickness—is responsible for this material's immunity to the effects of vibration and rough handling, its sustained high insulating effectiveness in service, and its unusually high salvage value. It is used at temperatures up to 700° F.



Steam lines insulated with J-M 85% Magnesia in a Texas sulphur plant.

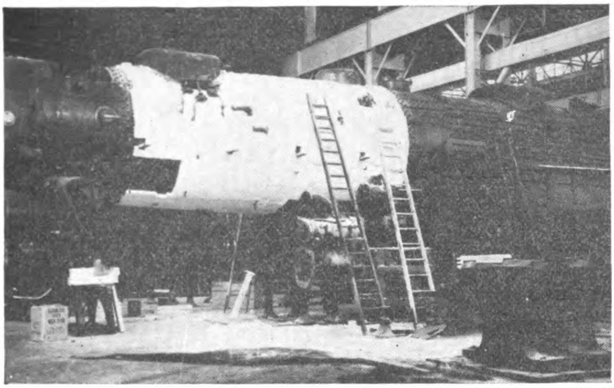


Dolomite limestone, shown at left greatly enlarged, has a thermal conductivity about twice that of concrete, but when it is converted into 85% magnesia, shown at the right at the same magnification, it becomes from twenty-five to thirty times as effective an insulation due to the pore space content being increased by chemical processes to 90 per cent of the total volume.

Super Fire-Felt for use at temperatures up to 900° F., is a light weight, efficient, resilient insulation made of felted asbestos fibre. It is designed for lining boiler tube doors and the air passages on ventilated furnace walls, and in other locations where a resilient insulation is required to withstand strains caused by expansion and contraction.

For insulating such equipment as low pressure heating boilers, and warm air ducts, where temperatures range up to 300° F., there is available Improved Asbestocel Sheets and Blocks. And for the insulation of low pressure steam and hot water heating lines in the same temperature range, Pre-Shrunk Asbestocel Pipe Insulation.

These Asbestocel Insulations are made of alternate layers of plain and corrugated asbestos felts built up to various thicknesses. This cellular type of insulation is efficient and highly economical for the purposes for which it is recommended.



J-M 85% Magnesia Lagging being installed on the boiler of a locomotive.

Rock Wool

The mineral most widely used as a basis for low temperature insulation is rock or mineral wool.

Mineral wool was first produced by Nature during an eruption of the volcano of Kilauea, which, native Hawaiian legend explained, was the goddess, Pele, holding court. After the crater had cooled, natives would venture up the mountain and collect strands of a wool-like substance which they reverenced as "Pele's hair", thought to have been torn out by the goddess in a rage.

Circle: *Circle:* From a man-made volcano comes rock
mineral wool, four inches of which is as effective
insulating the wall of a home as would *be eleve*
feet of solid stone. *Above:* In existing homes roc
wool, in nodulated form, is blown under pressu
into hollow walls and attic spaces. *Left:* For *ne*
construction rock wool is applied in the for
of batts.

Geological survey revealed this substance to be lava, blown into soft threads by the gigantic forces of the volcano. Today, at Johns-Manville factories, in "man-made volcanoes", molten silica minerals are blown by means of steam into silky fibres that are strikingly similar to "Pele's hair."

Insulation for Homes

This resulting Rock Wool, as it is known, is the most widely used material for insulating homes to keep out the heat in summer, and to keep valuable heat from escaping in winter.

Formed into batts for application in new construction, or into nodules fo blowing under pressure into the normall hollow walls of existing dwellings, fou inches of this Rock Wool are as effectiv an insulator as eleven feet of solid stone Tests have shown that a home insulate with this material will be up to 15° coole on the hottest summer days. In winte savings on fuel bills for a house so insulated range up to 30 per cent.

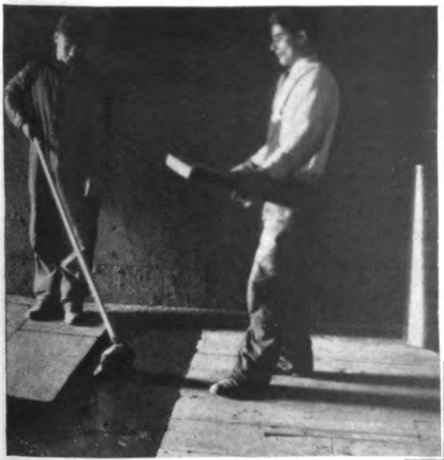
During the past decade or so Johns-Manville Rock Wool has brought new comfort and economy to many thousands of home owners throughout the country.

Low Temperature Insulations

The direct cause of most insulation failures in the low temperature or refrigeration range is infiltration of moisture laden air which condenses on the walls or pipes of refrigerated equipment and then freezes, causing disintegration of the insulating material. Thus, to be effective, over a period of time, an insulation for refrigeration service must possess the ability to resist this infiltration.

For low temperature insulation purposes the Rock Wool fibres are combined with a waterproof binding ingredient and molded into Rock Cork sheets and pipe insulation. Rock Cork, because of its [redacted] nature, and waterproofing binder, is highly moisture resistant, permanent and rot-proof. And, of particular importance where food stuffs are stored, it will not harbor vermin or rats, and cannot support the growth of bacteria or mold. Because of their many advantages, Rock Cork Sheets are used to provide sanitary, permanent insulation in meat packing plants, breweries, dairy and ice cream plants, oil refineries, and in other industries dependent upon refrigeration.

As an added protection against infiltration of moist air into Rock Cork Pipe Insulation, each section is provided at the factory with an hermetic seal. This is composed of a waterproof jacket firmly embedded in a coating of asphalt applied to the Rock Cork. This jacket is provided with a flap which is sealed down over the longitudinal joint at installation, making possible a finished job that is one continuous, seamless sheath of insulation, air and moisture-tight at every point.



Above: **Installing Johns-Manville Rock Cork Sheets. Many such installations are in perfect condition after more than thirty years of service.** ***Right:*** **Applying a section of J-M Rock Cork Pipe Insulation. Note the waterproof jacket with lap for sealing which is an integral part of the pipe covering itself.**

Other Low Temperature Insulations

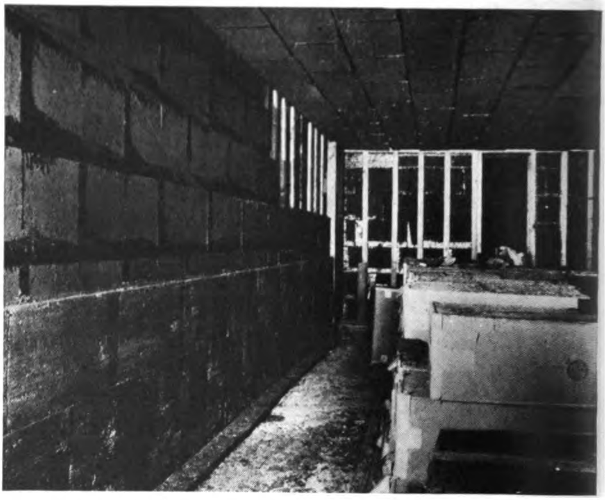
Another inherently water-repellent material is used for fabricating insulation designed for use in railroad passenger and refrigerator cars. This material is composed of chemically-cleaned cattle hair, felted between fabrics of various types. Its high insulating efficiency is due to the interlacing of the hair to form minute air pockets. Salamander and Hairinsul, for passenger and refrigerator cars, respectively, have been the standard insulation for this equipment for the past quarter of a century.

A more recent development for insulating railroad cars is J-M Stonefelt, a light-weight, inorganic material which is waterproof, incombustible and rot-proof, with the resiliency necessary to maintain its shape and high insulating efficiency indefinitely.

Hair Felt, built up in multiple layers, also provides an economical and efficient means of protecting water pipes from freezing where the pipes are subjected to severe conditions. This insulation con sists of the required number of layers, depending upon conditions, bound in place on the pipe by means of heavy jute twine and finished on the outside with a waterproof jacket.

Another form of insulation, known as Anti-Sweat Pipe Insulation, is used on service water lines to keep cold water cold and to prevent sweating and dripping. It is made of laminated wool felt, protected inside and out with waterproofing felts.

Also available for service water piping is J-M Pre-Shrunk Wool Felt Insulation, made of specially indented wool felt and provided with a dual-service liner to make it suitable for use on either hot or cold service water lines. Treated to prevent moisture absorption in storage, it eliminates objectionable shrinkage in service. It is supplied in either canvas or flat aluminum finish, the latter being especially designed for use where pipes are exposed to view.

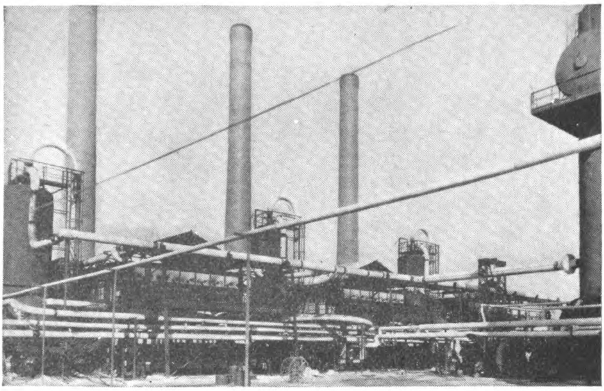


One of more than thirty installations of Rock Cork in New York City plants of the Dairymen's League. The dairy, ice cream and other food products industries have learned to depend upon J-M Rock Cork sheets for efficient, permanent insulation of cold rooms.

Thickness of Insulation

So far, the most important types of insulations along with a general picture of the service conditions for which they are fitted, have been discussed briefly. One of the most important considerations in the application of any insulation, however, has not been touched upon at all. This is the thickness of insulation which should be installed.

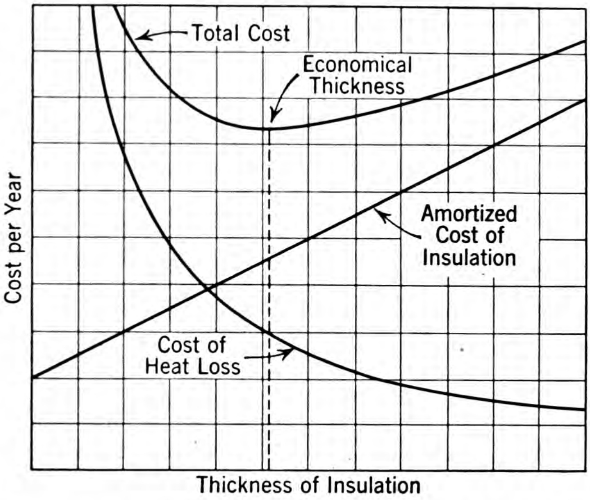
Wherever insulation can be used to advantage, there is, of course, a definite thickness of insulation that will be most economical to apply. For example, in insulating a furnace wall, if one inch of insulation is applied, the heat loss through the wall will be cut tremendously as compared to the heat loss through an uninsulated wall. Yet, at the same time, there still may be a very



J-M Asbesto-Sponge Felted Pipe Insulation in an oil refinery. This material is unequalled in insulating efficiency and durability. For use outdoors it is supplied with an integral waterproof jacket.

costly waste of heat. Each additional inch of insulation will cut the heat loss further, but by a decreasing increment, until eventually if enough insulation is applied, the heat loss can be reduced to a barely measurable degree.

However, it is not economical to apply insulation to this thickness because the return on the investment in the last increments of thickness would not be satisfactory. The economical thickness is that for which the yearly cost of the insulation (fixed charges such as interest, depreciation, etc.), added to the yearly cost of heat loss, is a minimum.



The economical thickness of insulation is that for which the combined yearly cost of insulation and heat loss is at a minimum.

In the insulation of low temperature equipment, a much heavier insulation than is customary for high temperatures can be used economically due to the fact that a ton of refrigeration, the equivalent of 288,000 B.t.u. per 24 hours, costs approximately ten times as much as the same number of B.t.u. produced for heating purposes.

In some industrial processes where it is necessary to control temperatures within close ranges in order to produce desired results, insulation of greater thickness than that which could be justified solely on a basis of economy due to heat saved, must be used.

The selection of the economical thickness of insulation to be used, as well as the type and method of application, is where the insulation engineer performs his greatest service to industry.

Through years of specialized training, and through the fund of data built up by Johns-Manville during three quarters of a century of experience and research in solving insulation problems, he has been equipped to aid industry in this all-important task of solving heat conservation problems.

It is due in no small measure to the efforts of these men that today, wherever heat or refrigeration is used in industry, whether in a power plant, a cold storage warehouse, a steel mill, an oil refinery or a glass plant, insulation is recognized as an essential to economical operation.

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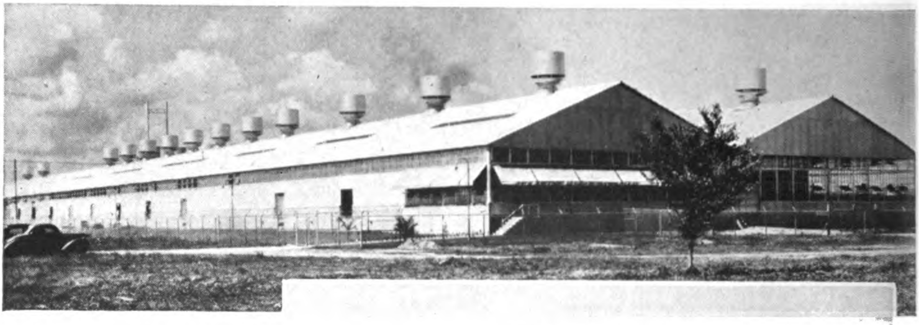
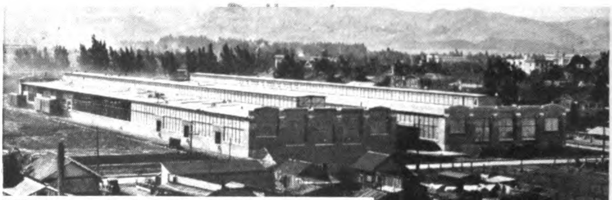
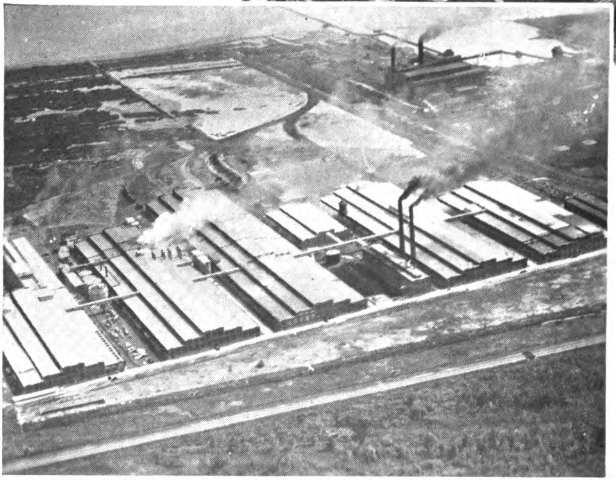
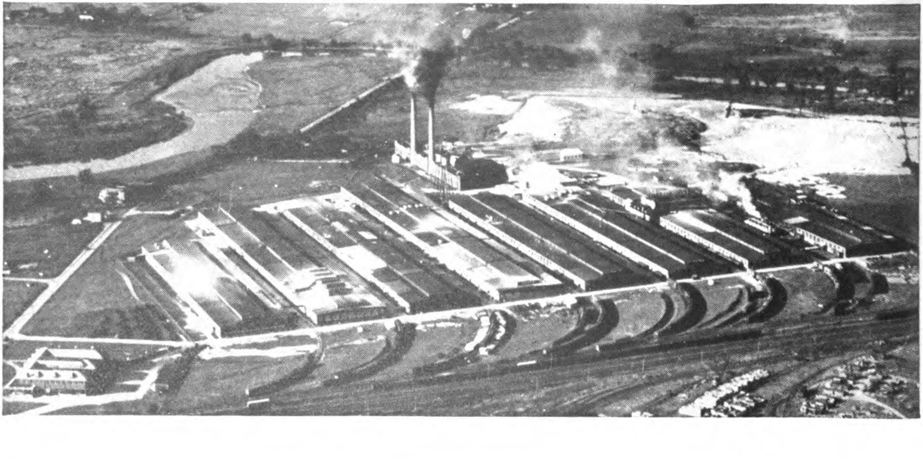




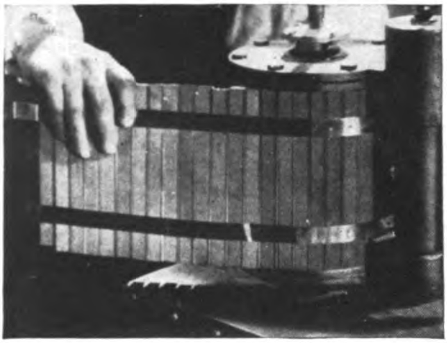
Four of the 12 Johns-Manville plants operated in the United States and abroad are pictured on this page. *Above* is a new factory opened at Marrero, La., in 1936. *Right* is the Johns-Manville factory at Pittsburg, Calif.



Left: One of the two principal factories of Johns-Manville is located at Waukegan, Ill. This air view shows a portion of the plant which includes the office building, power plant, pumping station and seven manufacturing buildings. *Below:* Almost a "twin" to the Waukegan plant is the Manville, N. J., plant which includes an administration building, power house and nine manufacturing buildings. Here, also, is situated the J-M Research Laboratories.



PROFITS from Heat Conservation



A scene from the Johns-Manville sound motion picture "Heat and Its Control," showing how James Watt insulated his primitive steam engine with strips of wood.

WHEN James Watt bound strips of wood around the boiler of his steam engine in an attempt to conserve heat to do useful work, the first recorded use of insulation for this purpose was brought into being.

Wood, as insulation, had the advantages of being plentiful and cheap, but it was as inadequate compared to today's heat conservation materials, as was Watt's tiny engine compared to the gigantic and powerful modern-day steam generating equipment.

Of course in Watt's time, and for nearly a century afterward, insulation was not thought to be particulary essential. There was an abundance of fuel to be had at very low cost, and so little was known of the true nature of the mysterious force, heat, that in many instances no necessity for insulation was seen at all.

Since that time, however, industry has learned more and more how insulation can be used to advantage not only in conserving available energy and in keeping production costs low, but in making possible many modern industrial processes based on reactions which take place within narrow temperature ranges, and which could not be successfully carried on at all without the close control made possible by insulation.

In fact, today, wherever heat or refrigeration is used in industry, there insulation also will be found. Even in those places where relatively recently it was thought that insulation would be uneconomic because the unusually high temperatures employed might cause the rapid burning out of refractory linings by preventing free dissipation of heat, insulation has come to be widely used.

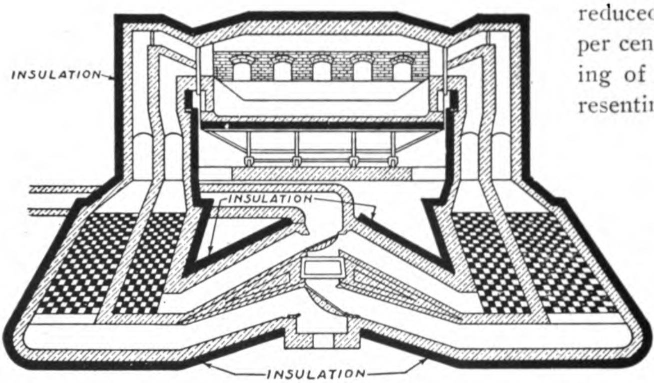
Insulation in the Steel Industry

A good example of this is in the steel industry.

For many years, insulation had been used to minimize heat losses from the regenerative sections of open hearth furnaces, but it was believed that to insulate over the top of the furnace itself would result in much earlier destruction of the refractory roof and consequently result in greater over-all cost than if no insulation were used.

It was only a few years ago that the first open hearth furnace roofs were insulated—as an experiment. Heat losses were immediately reduced to half their former extent, effecting large savings in production costs. And, surprisingly enough, it was found that the insulation, far from causing premature failure of the refractory roofs, actually increased their life in practically every instance.

The success of these first installations soon led to similar ones in mills throughout the country. Today, this last citadel of heat waste in the steel industry has practically disappeared, and insulation of the open hearth system, from the furnace,



Perspective cross-section of the open hearth system, showing location of insulation.

itself, to the flues which carry the exit gases to the stack, is now standard steel mill practice.

The savings insulation assures are sufficient to repay its cost in a very short time, and the cost of making steel is appreciably reduced. Air infiltration is also minimized, more positive control of the entire operation can be maintained, and the time required for making steel is shortened.

That all of these advantages are derived through the use of insulation is borne out in the many insulated open hearths built in recent years. At one mill, for example, insulating the side walls and arches of regenerators and flues on a 25-ton furnace with four and one-half inches of J-M Sil-O-Cel Natural Brick reduced the oil consumption 23.4 per cent, effecting an annual saving of over $11,000.00 and representing a yearly return on the investment of more than 400 per cent.[1]

A number of modern open hearth installations are equipped with waste heat boilers. In such cases it is even more important to insulate, as the economy of operating these boilers is dependent upon conserving heat throughout the system so that "waste" gases may be delivered to the boiler with the greatest possible heat content.

Soaking pits, used in the steel industry to bring ingots to a uniform temperature preparatory to rolling, are also operated on the regenerative principle. Insulation is installed in the same general way as in the open hearth, with 4 inches of Sil-O-Cel C-3 Concrete in the base and Superex Blocks, Sil-O-Cel Natural Brick or JM-20 Brick in the walls and over the

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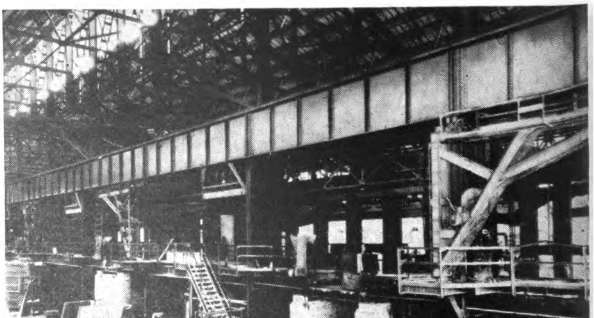
[1] Details are available in Johns-Manville Performance Report No. 28, supplied on request.



Four 100-ton open hearth furnaces in which the regenerative systems were insulated throughout with Johns-Manville materials. Such insulation improves performance, increases production and lowers operating costs.

tops. Such insulation on one pit in a large steel mill effected a saving of over $9,000.00 per year, representing a net annual return on the investment of over 541 per cent.[2] In this case a direct comparison could be made with an uninsulated pit and the lower fuel consumption was sufficient to repay the cost of insulation during the first ten weeks of operation.

Hot Blast Stoves

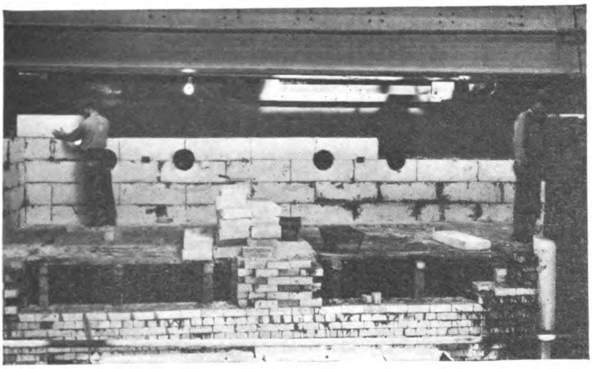
Insulation in steel mill hot blast stoves increases the efficiency to a considerable extent and serves as a cushion to take up expansion and contraction of the refractory lining on alternate heating and cooling. It also protects the steel from excessive temperatures which increases the life of the shell considerably. In hot blast stoves Superex Blocks are installed between steel shell and brick lining. In many cases the unusual heat resistance of Superex permits the thickness of the refractory to be reduced by one 4½-inch course.

To blanket the entire system against excessive heat losses, and greatly increase the efficiency of the regenerative process, a three-inch layer of Superex Blocks or a 4½-inch course of Sil-O-Cel C-22 Brick behind a course of fire brick are used in the hot blast main connecting the stoves with the blast furnace, as well as in the bustle pipe which encircles the furnace at the tuyeres and through which the heated air is introduced into the furnace.

In the operation of steel mill re-heating equipment and other types of industrial furnaces and ovens, adequate insulation pays for itself in fuel savings in an amazingly short time. It also makes possible closer temperature control, reduces air infiltration, assures better working conditions and, in many cases, appreciably improves the quality of the product turned out by the furnace.

Stripping crane removing hot ingots from a soaking pit. This pit was insulated with 4 inches of Sil-O-Cel C-3 Concrete in the base and Superex Blocks and Sil-O-Cel Natural Brick in the walls and over the top.

In the higher temperature furnaces, operating above 2000° F., Superex Blocks or Sil-O-Cel Brick are usually applied behind the refractory in walls and over the fire brick roofs. For bases, Sil-O-Cel C-3 Concrete is practically standard construction.



Installing Superex Block Insulation in a soaking pit in a large Eastern steel mill.

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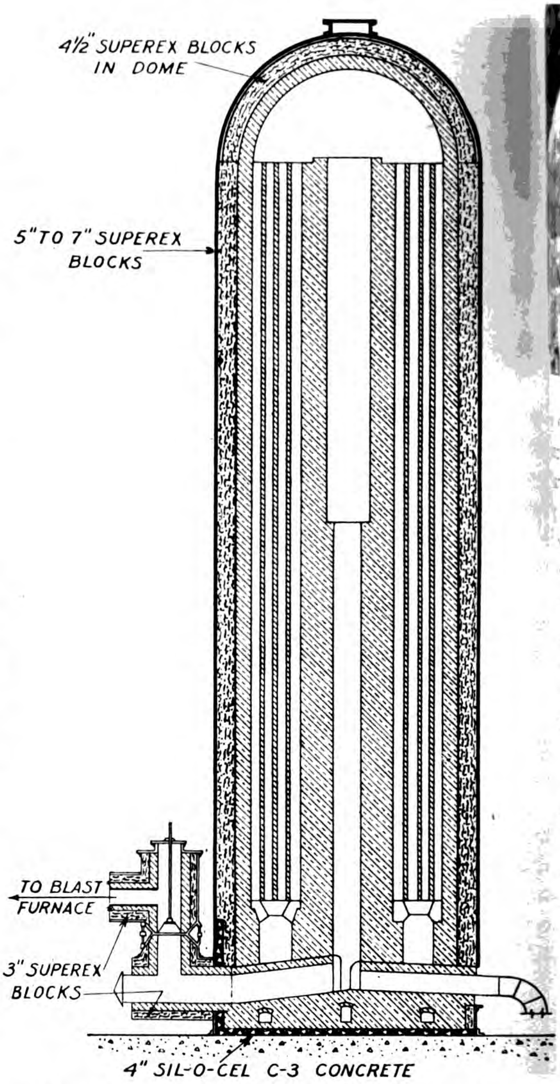
[2] Details are available in Johns-Manville Performance Report No. 25, supplied on request.

On intermittent furnaces operating at temperatures up to 2000° F., when not subjected to mechanical abrasion or slag action, Sil-O-Cel C-22 Brick and JM-20 Brick, used as insulating refractory brick, effect large savings in heat capacity losses and permit much faster heating up. This type of design also results in reduced construction costs, improved furnace performance and minimum heat losses

Insulation in the Cement and Lime Industries

Probably the most severe service that is required of high temperature insulation occurs in the lining of rotary cement and lime kilns. The insulation is called upon not only to resist the effect of high temperatures but also to maintain its strength and insulating qualities under the enormous stress incident to expansion and contraction of the fire brick lining. In addition, it must bear the continued impact of clinker falling through the kiln in its rotation.

Successful insulation depends not only on the use of the right material but also on proper installation of the insulation and the refractory lining to prevent circumferential slippage and to localize longitudinal movement.



Johns-Manville insulation recommendation for hot blast stoves and mains.

It is customary to leave 45 feet at the hot end of all kilns uninsulated and on wet process kilns, 20 feet at the wet end. The remainder of the kiln surface is insulated with two and one-half inches of Superex Blocks installed between the refractory lining and the steel shell. Longitudinal and circumferential rows of refractory blocks extend through the insulation to the shell at suitable intervals to wedge the lining permanently in place.

The results obtained in a Clinchfield, Georgia, cement plant are typical of those reported for other mills. At this plant careful fuel consumption records show that Superex Blocks on two 10 by 175 ft.

Left: Rotary cement kiln being insulated with Superex Blocks between steel shell and refractory lining. Superex Blocks are practically standard insulation for the severe service encountered in lime and cement kilns. *Below:* Applying Superex Blocks to top of a rectangular kiln for the firing of face brick.

rotary kilns reduced coal consumption five pounds per barrel of cement, a saving of $4,800.00 per year, representing an annual return of 120 per cent on the investment in insulation.[1] It should be noted that this figure does not include further savings due to increase in temperature of exit gases at the waste heat boilers, but covers only the decrease in fuel consumption at the kilns.

Three rotary lime kilns at Sault Ste. Marie, Michigan, were insulated with Superex Blocks in the same manner and showed a net annual saving of $7,800.00, a return of 158 per cent per year on the cost of insulation.[2]

Insulation in the Ceramic Industry

High temperatures are so intimately associated with the manufacture of brick, tile and pottery that adequate insulation is recognized as an essential in the design and construction of kilns of the permanent type. And, wherever comparative fuel consumption records have been kept, insulation has been shown to be a decidedly worthwhile investment.

In one instance, Superex Blocks over the tops of rectangular kilns returned their entire cost in fuel savings alone during the first year.[3] Such savings ($5,000.00 for six kilns in this particular case) are within the reach of any plant now operating uninsulated periodic kilns, for crown insulation can usually be applied just as easily and economically on old kilns as on new construction. Insulation on crowns alone has, in practically every case, shown a reduction in fuel consumption of at least ten per cent.

Continuous tunnel kilns in particular are always thoroughly insulated because of the great areas exposed to radiation. Sil-O-Cel Powder, Sil-O-Cel Brick and Superex Blocks have been used in the great majority of tunnel kilns built during the past twenty years.

Glass Plant Insulation

In the making of glass, heat is used in all stages of the process from the melting of the batch to the annealing of the finished product, and insulation plays an important part in reducing costs and in

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[1] Details in Johns-Manville Performance Report No. 36, supplied on request.

[2] Details in Johns-Manville Performance Report No. 58.

[3] Details in Johns-Manville Performance Report No. 35.

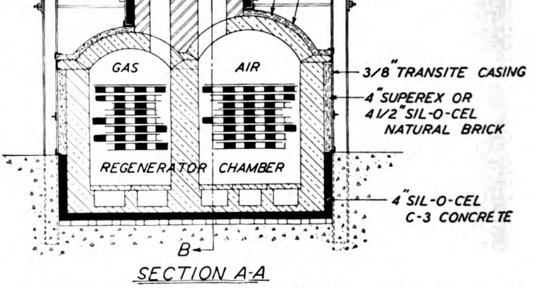
Four electrically heated lehrs for annealing glass, heavily insulated with Sil-O-Cel Super Brick as the inner lining, backed up with Sil-O-Cel Natural Brick. Ten inches of insulation was used in bottom, sides and top.

improving operating performance of the equipment. In the glass plant insulation is used on such equipment as melting furnaces, producer gas mains, and annealing lehrs.

Whether or not insulation should be used on walls and crowns of glass tanks is a question to be considered specially for each individual job. This matter is now receiving a great deal of attention in the glass industry due in part, perhaps, to the excellent results which have attended the use of insulation on open hearth roofs in the steel industry. There are a number of insulations including Superex Blocks, and Sil-O-Cel Brick and Powder, which will successfully resist the temperatures encountered outside the refractory.

Sil-O-Cel C-22 Brick on the refining end of continuous tanks also offer an excellent opportunity for fuel savings which should be possible for every plant. In day tanks also, insulation has been used with uniformly beneficial results. A 4½-inch course of Sil-O-Cel C-22 Brick in the walls and a 2½-inch course in the base and over the crown will shorten the melting time, reduce fuel consumption and minimize troubles due to vitrified or cordy glass.

Insulating the regenerators of glass melting furnaces results in large fuel savings due to reduction in heat losses and the elimination of air infiltration. For example, one plant, by insulating the walls of the regenerators on one furnace with Superex Blocks, was able to reduce the fuel consumption by 26.5 per cent, a saving of $8,880.00 per year and an annual return on the investment of 655 per cent.[1]



J-M insulation recommendation for glass tank regenerators and uptakes.

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[1] Johns-Manville Performance Report No. 11.

Oil Refinery Insulation

Insulating materials are used extensively in the oil-refining industry for improving the operation of stills, towers, hot and cold tanks, brine coolers, chillers and cold rooms. High temperature insulation is also used in oil refineries for the furnace settings of stills.

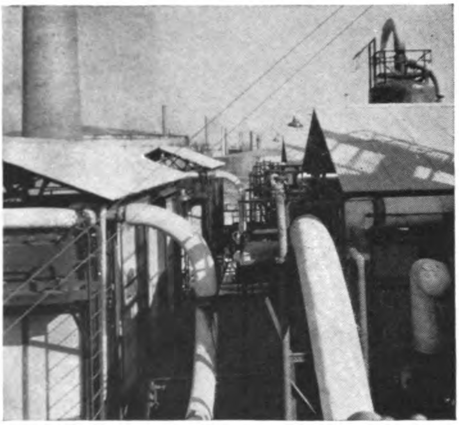
Asbesto-Sponge Felted, J-M 85% Magnesia, Superex Combination Block Insulation and Banroc (rock wool) Blankets are the most widely used materials for insulating the exposed heating surfaces of stills, towers and other fractionating equipment. Oil refinery furnaces are usually insulated outside the refractory with either Superex Blocks alone, or Superex-Magnesia Combination Block Insulation.

For furnace bases, four inches of Sil-O-Cel C-3 Insulating Concrete have proved highly effective. This material is also used for the insulation of tube doors and to protect metal work on tube plates and tube supports.

Refrigeration is, of course, extensively used in various processes in oil refining. In this industry refrigerated equipment is located both indoors and out, and of necessity an insulating material must be moisture resistant, in addition to possessing a low conductivity. J-M Rock Cork fulfills both of these requirements. Rock Cork sheets and lagging are used for insulating brine coolers, chillers, cold rooms and refrigerated tanks; and Rock Cork Pipe Covering for insulating cold lines.

Insulation in the Brewery

The present-day brewery, to operate economically and on a competitive basis, must be equipped to take advantage of proved modern methods of decreasing operating costs. Insulation, naturally, is a vital economy measure and one of the major essentials to efficient operation.



Johns-Manville insulating materials are widely used in the oil refining industry where they in no small measure aid in the efficient operation of heating and refrigerating processess used in transforming crude oil into finished petroleum products.

Insulation of low temperature equipment and storage rooms is especially important because of the high cost of refrigeration and because of the necessity of controlling temperatures within a relatively narrow range.

In the case of heated equipment in the brewery fuel cost is one of the principal items of expense and the problem of heat conservation is a matter of major consequence. In the boiler room, insulation of the boiler furnaces reduces heat losses, minimizes air infiltration and assures better working conditions. Insulation on boiler drums and steam lines pays for itself many times over in fuel savings.

Brew kettles, cereal cookers, mash tuns, hot water tanks and similar equipment, all can be made to operate more economically by the careful selection and application of insulating material of the proper type and thickness.

Paper Mill Insulation

The Biggs Rotary Bleaching Boiler offers a good example of how savings may be made in the paper mill through insulation. Insulating this equipment with one and one-half inches of J-M 85%

Installation of Rock Cork Sheets in the Miller Brewing Company, at Milwaukee, Wisconsin. A total of 150,000 board feet of this insulating material was used in this one installation.

Magnesia Blocks, with a finish of a suitable cement, will pay, according to careful calculations of comparative heat losses, an annual return on the investment of about 60 per cent even when fixed charges against the insulation are based on amortization in only five years.

In pulp and paper mills as in many other plants and industries, however, power plant equipment and steam lines obviously represent the best opportunities for economy through insulation. The trend toward higher steam pressure in connection with modernization programs places a special premium on thorough investigation of the adequacy of existing pipe insulation. Increased pressures almost invariably demand re-insulation of piping if the full benefit is to be derived from modernization.

Insulation in the Power Plant

Public utility power plants that derive their sole revenue from the sale of power, have found it imperative to use efficient insulation, for every B.t.u. of heat saved is reflected in their earning statements.

That this necessity for thorough insulation has been recognized by power plant operators is evidenced by the fact that one of the first applications of high temperature insulations was in boiler settings. At the present time practically all boilers have insulated settings.

Where solid refractory walls are used in the furnace, the insulation consists either of Sil-O-Cel Natural Brick laid between the fire brick and outer red brick wall in so-called "core wall" construction, or of C-22 Brick or Superex Block as a veneer on the outside of the refractory walls.

In the last few years, the capacity of boiler furnaces has been greatly increased by water-cooling the furnace walls. This type wall is usually constructed with circulatory tubes which carry the water through the walls. In the Bailey type water wall, refractory blocks are clamped to these tubes, and the studs are tapped on 24-inch horizontal centers and 18-inch vertical centers to receive the studs which support the exterior casing. Plastic insulating cement is pressed in place on the wall to level the surface and just cover the metal work, and two layers of Superex Blocks are applied broken joint method between the casing studs. Transite asbestos-cement panels, two feet wide and three feet high, are then fitted in vertical rows against the wall and secured at their edges by steel battens fastened to the studs.

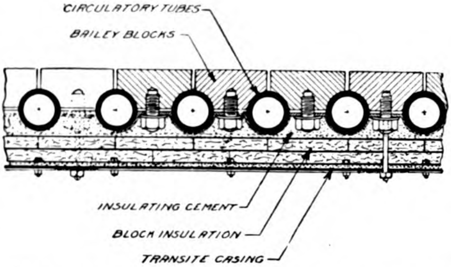
Air-cooled furnace walls offer another interesting example of current construction. The casing over the airways consists of removable and replaceable panels composed of outside sheets of three-eighths inch Transite, inside sheets of one-fourth inch asbestos mill-board and an intermediate layer of one inch insulating blocks. This construction combines adequate insulation with high heat resistance, impermeability, durability, and a permanently attractive exterior surface.

J-M 85% Magnesia Blocks are the most widely used for the insulation of boiler drums and such auxiliary power plant equipment as feed water heaters, pumps, economizers and superheaters. Steam turbines are insulated with J-M 85% Magnesia Blocks, Superex Combination Insulation or Asbestos Blankets.

The importance of insulating flues and breechings in power plants is now quite generally recognized. By insulating, draft is improved and working conditions about the equipment are made more comfortable. Breechings are insulated on the inside or the outside, depending on the circumstances of the individual installation.

Stacks in hotel, stores, office buildings, and the like, are insulated not only to prevent rooms adjacent to the stack shaft from becoming too warm, but also to reduce the fire hazard. Stacks are usually insulated on the inside of the steel.

Steam lines in power plants are always thoroughly insulated against heat loss. For temperatures up to 600° F., 85% Magnesia has been the standard insulation for more than 40 years. Asbesto-Sponge Felted is used for outdoor lines, or wherever maximum durability combined with high insulating efficiency is required.



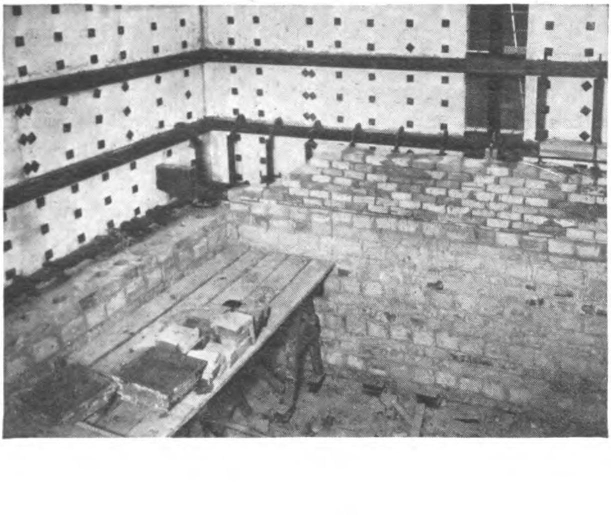
Horizontal section through a Bailey water-cooled boiler furnace wall.

To insulate superheated steam lines at temperatures above the temperature ranges of 85% Magnesia and Asbesto-Sponge Felted, the use of an inner layer of Superex in combination with these other materials is standard practice in most plants.

Heating boilers of the H.R.T., fire-box, and cast-iron sectional types and the drums of water-tube boilers are insulated with J-M 85% Magnesia Blocks, one inch thick, for steam pressures up to 25 pounds; one and one-half inches thick, for pressures up to 100 pounds; two inches thick for pressures up to 200 pounds; and two and one-half inches thick for pressures over 200 pounds.

Gas Plant Insulation

In the manufacture of gas, whether it is water gas, coal gas, oil gas, or producer



Interior of insulated Transite casing erected outside air-cooled furnace walls. Brickwork is laid after the casing is completed. This construction provides adequate insulation with high heat resistance, impermeability, durability and a permanently attractive exterior surface.

gas, insulating materials are on the job, helping to cut production costs.

In the successful operation of coal gas retort benches, maintaining a uniform effective temperature in the carbonization chamber of a bench as well as efficient operation of the producer are important factors. Insulation of benches and of producer take-offs and mains assists greatly in assuring proper control of these factors and in reducing operating costs.

For producer take-offs, soot catchers and mains, 2½-inches to 4-inches of Superex Blocks or a 2½- or 4½-inch course of Sil-O-Cel Natural Brick or JM-20 Brick are the standard recommendations. Such insulation quickly returns its cost in fuel savings, holds the gas at high heat value and materially reduces tar deposits.

Superex Blocks, Sil-O-Cel Coarse Grade, Fibro-Cel and Sil-O-Cel C-3 Concrete have been used in the great majority of water gas set installations during the past twenty years.

Naturally in the short space of these pages, no attempt could be made to adequately describe the many uses to which insulation is put by industry today.

Data Books Available

This detailed information has been made available to the operators of modern industrial plants, however, in a series of eighteen books, varying in size from 64 to 208 pages. Any of these books will be mailed on request, free of charge. Titles are as follows: DS-600, Automotive Industry (Factory); DS-601, Brewery; DS-602, Chemical Industries; DS-603, Clay Products Industry; DS-604, Cold Storage Industry; DS-605, Distillery; DS-606, Food Products Industries; DS-607, Foundry; DS-608, Gas and Coke Industries; DS-609, Glass Industry; DS-610, Industrial Furnaces and Ovens; DS-611, Lime and Cement Industries; DS-615, Marine Service-Engine Department; DS-612, Non-Ferrous Metals Industries; DS-616, Power Plant; DS-613, Pulp and Paper Industry; DS-614, Vitreous Enameling Industry.

Boiler breeching being lined with two-and-one-hal inches of insulating brick and a facing of semi refractory cement.

Each book contains detailed recommendations for insulating the equipment found in each individual industry. Not only do they specify the insulating materials best suited to the particular purposes, but recommended thicknesses are also given. Specifications and drawings provide details of application and the materials involved are also described together with information as to efficiencies, temperature limits, sizes and weights.

In these books is contained the knowledge of insulating materials and insulation methods gained by Johns-Manville during more than three quarters of a century of research and experience in the control of heat losses.

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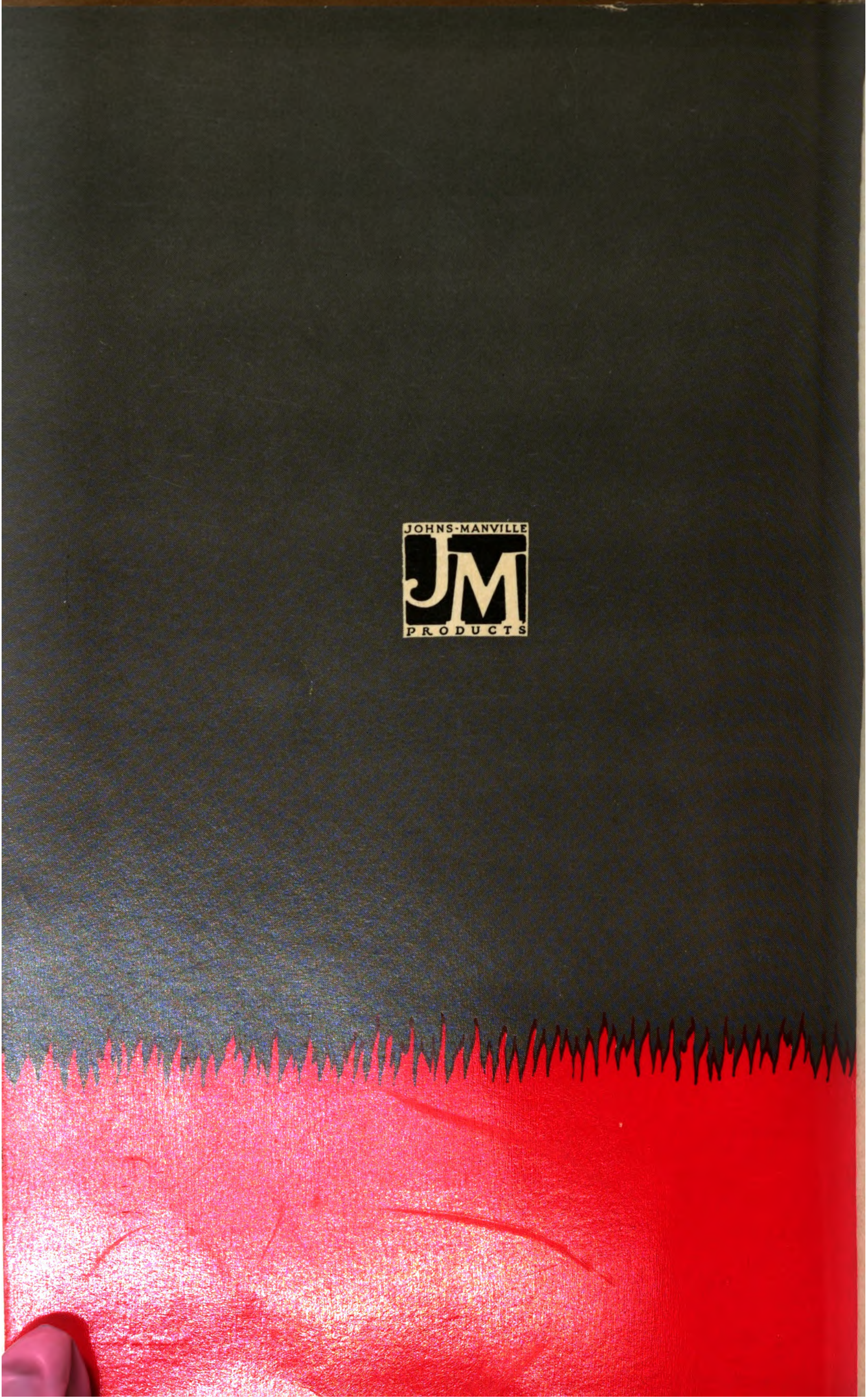
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