RADIANT HEATING

These two photographs show an installation of Copper tube in a home being constructed and the living room after the completion of the home.

With the mercury kissing the zero mark this young lass attired in a bathing suit is preparing to put on her skiis at Sun Valley before a take-off on the snow covered slopes. The rays of the sun keep her comfortably warm.

Photo courtesy Steve Hannagan

COPPER TUBE FOR RADIANT HEATING

"THERE IS NOTHING NEW UNDER THE SUN," is an old adage and this is typically true of Radiant Heating. For Radiant Heat is as old as the Sun and Earth, the surface of the latter, as everyone knows, being kept warm by Radiant Heat from the sun. Delving into History we find that the early Romans were perhaps the first to harness heat in the form of radiation. They called it hypocaust. We know it as Radiant Heating. Excavations of the famous baths at Pompeii and other Roman cities which flourished before Christ have unearthed Copper pipe which apparently was used to warm the floors and walls. After being buried for centuries, this oldest of the metals of commerce, was still in an excellent state of preservation.

Within the next decade it is estimated that from 10,000,000 to 12,000,000 new homes will be built in the United States. In the construction of millions of these homes Copper tube will be used for heating, just as the Romans used Copper centuries ago. Radiant heating systems are not a new-fangled idea by some modernistic architects and heating engineers. There are numerous successful installations of Radiant Heating, using Copper tube, in this country today. This form of heating has proved satisfactory for more than a half century on Continental Europe, in England and in the United States.

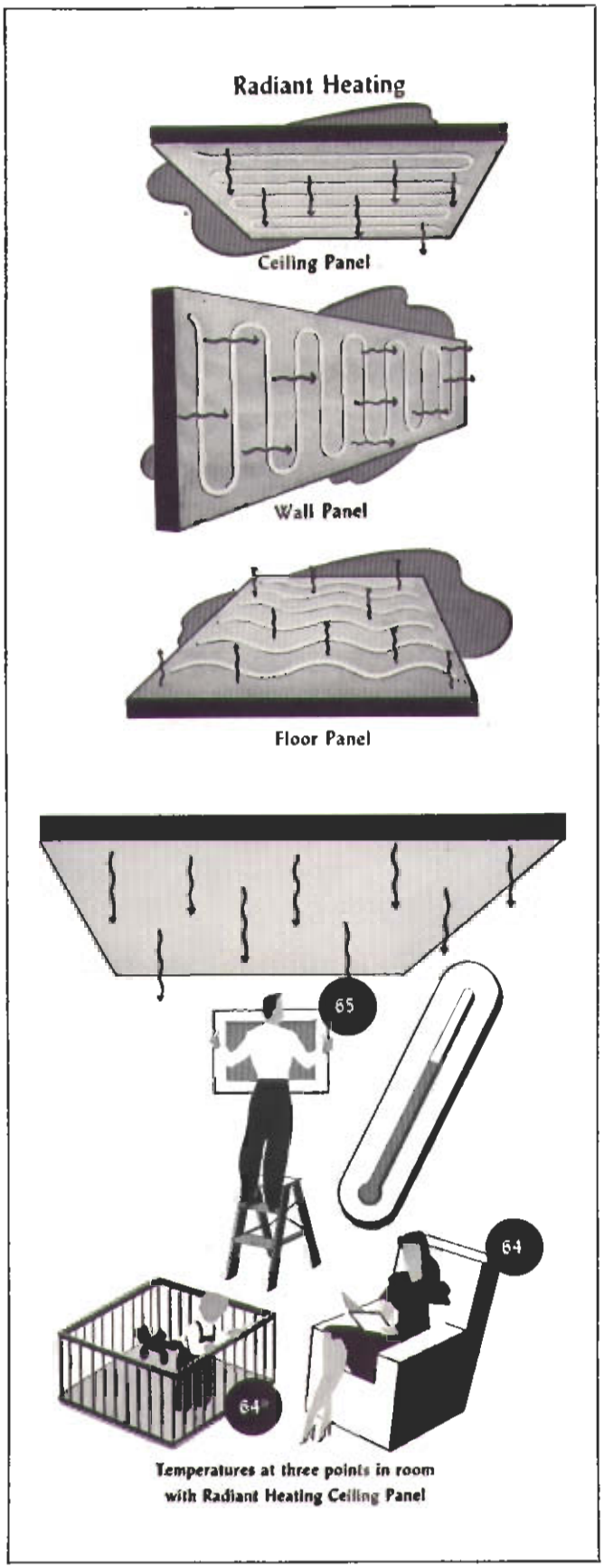
HEATS THE BANK OF ENGLAND

Among the first modern systems of radiant heating was one installed in England during the early part of 1900 by Professor A. H. Barker. Since it proved most satisfactory this type of heating has been generally used in Great Britain with the exception, of course, of the War years when all but essential building in that country was postponed so that its factories could turn out the materials to defeat the Axis Powers.

Perhaps the most outstanding radiant heating installation in England was completed after the end of World War I. This installation was made in the Bank of England under the direction of Dr. Oscar Faber. Copper pipe was used in the construction of this extensive system. This pipe was embedded in the concrete floors in continuous coils devoid of joints, excepting at the connection to the risers. At this point they were screwed to a valve which was accessible and connected to the risers by a short welded pipe. Care was taken to provide a first class key between the concrete ceiling and the plaster by laying on the forms lengths of rubber sheeting with raised ribs ¼ inch by ½ inch at 2½ inch centers, which, when the forms had been stripped, would be peeled off and leave a ribbed ceiling giving excellent adhesion for the plastering. This, according to Dr. Faber, has proved entirely satisfactory and there has been no trouble in connection with the heating system in the Bank.

The Bank is also cooled in the summer months by the same system. The water that circulates through the coils is from artesian wells and is relatively corrosive and that is the reason Copper was used throughout for the entire system.

Right—Radiant Heating installations provide more room in the home while the infiltration of dirt is less requiring less housework and it also does not require drapes to be cleaned each spring.



FIRST INSTALLATION IN AMERICA

Some years after radiant heating had been introduced in England, Professor Theodore Crane of Yale University (School of Fine Arts) designed what is perhaps the first radiant heating system in this country. It was not, however, until after World War I and just before the entrance of the United States in World War II that this type of heating was beginning to be used on a substantial scale here. Between the two World Wars scores of such installations were made in this country, particularly in California, by the firm of Robert Bruen & Son of Oakland, which is today among the leading firms specializing in such installations for all types of buildings – homes, factories, hospitals, schools and even in swimming pools. This firm uses Copper tube exclusively in all its installations and Mr. Bruen states that these installations have all given eminent satisfaction. Their record of performance from the standpoints of comfort and economy have been outstanding.

With the end of World War II when building products, particularly Copper and Brass, were released for peace-time uses, which made possible construction of homes and other types of buildings, the use of Radiant Heating has spread to every section of the country. Today thousands of homes being constructed will have such installations.

On the drafting boards of well-known architects throughout the nation are plans for the construction of thousands of homes and other types of buildings in which Radiant Heating systems will be used and in which Copper tube will be specified.

ADVANTAGES OF RADIANT HEATING

When the free-standing conventional type of hot water or steam radiation is used about 70 to 85 percent of the heat is transmitted by convection, the remainder by radiation. In Radiant Heating the average approximates 40 percent by convection and 60 percent by radiation. Where the rooms are heated by means of warm air the heat transfer takes place principally by convection. Sometimes even in such systems there may be an area in a wall, the ceiling or the floor, which becomes much warmer than the remainder of the room because there is a chimney or a hot-air flue in or near it, or because a hot blast of air constantly impinges against it, and in such cases the excess heat is dissipated into other parts of the room of the building by radiation.

Radiant heating in contrast with the conventional systems of heating relies mainly on heat transfer by radiation from the walls, the ceilings or the floor,

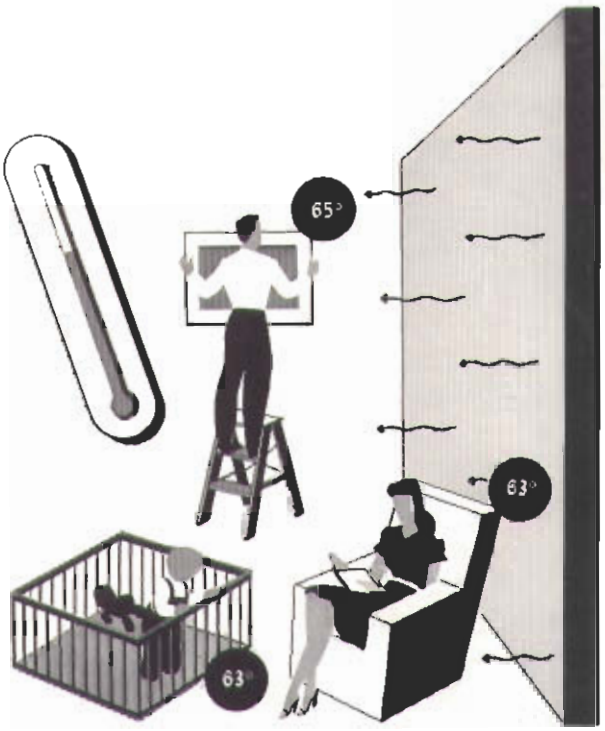
the temperature of which is raised above that of the space they are called upon to heat by means of hot water or steam pipes, by electrically heated wires, or by warm air flues concealed inside. The air in the immediate vicinity of these heated areas will absorb relatively more heat than farther away. The resulting slight difference in air temperature even in a Radiant Heating installation will set up a slight turbulence of air and cause mild air currents, thus distributing some of the heat by convection.

RADIANT HEATING AND HEALTH

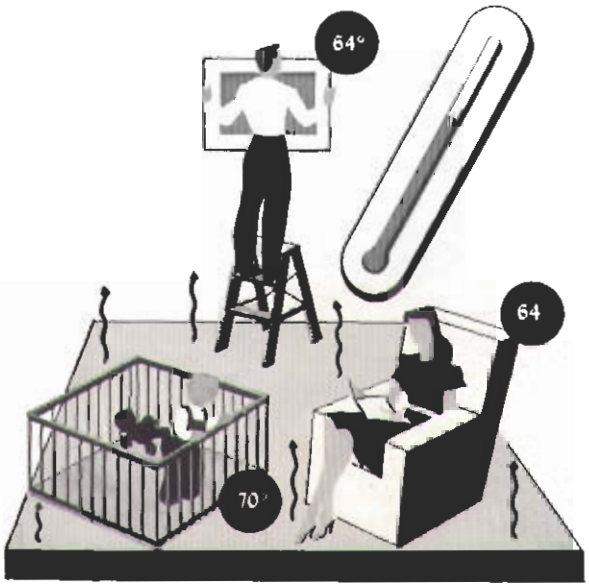
Eminent physicians emphasize that an individual's health is much better, his energy and comfort greater, when atmosphere surrounding him is rather cool; when the sun bathes him in its rays and the clothing is moderately warm which prevents the heat blanket normally clinging to him from being torn away. These are conditions which make the human being so full of "pep" during the advent of spring. Radiant Heating stimulates these healthful conditions and gives the atmosphere in the home or other type of building the tang of an out-door bright sunny spring day. In contrast is the atmosphere of an overheated room, which, while not actually detrimental to health, instead of being invigorating and stimulating in the activities normally carried on, may have a tendency to cause a feeling of weariness. As a result persons in homes, stores, offices and factories with radiant heating are really enjoying springlike atmosphere during winter months.

Where Radiant Heating systems are used the temperature of the surrounding air may normally be held substantially lower than with the conventional systems, so that persons in the room, while receiving radiated heat from the floor, surrounding walls or from the ceiling, breathe refreshing cool air. They thus experience the feeling which is associated with being out of doors on a clear, cool morning with no high winds blowing.

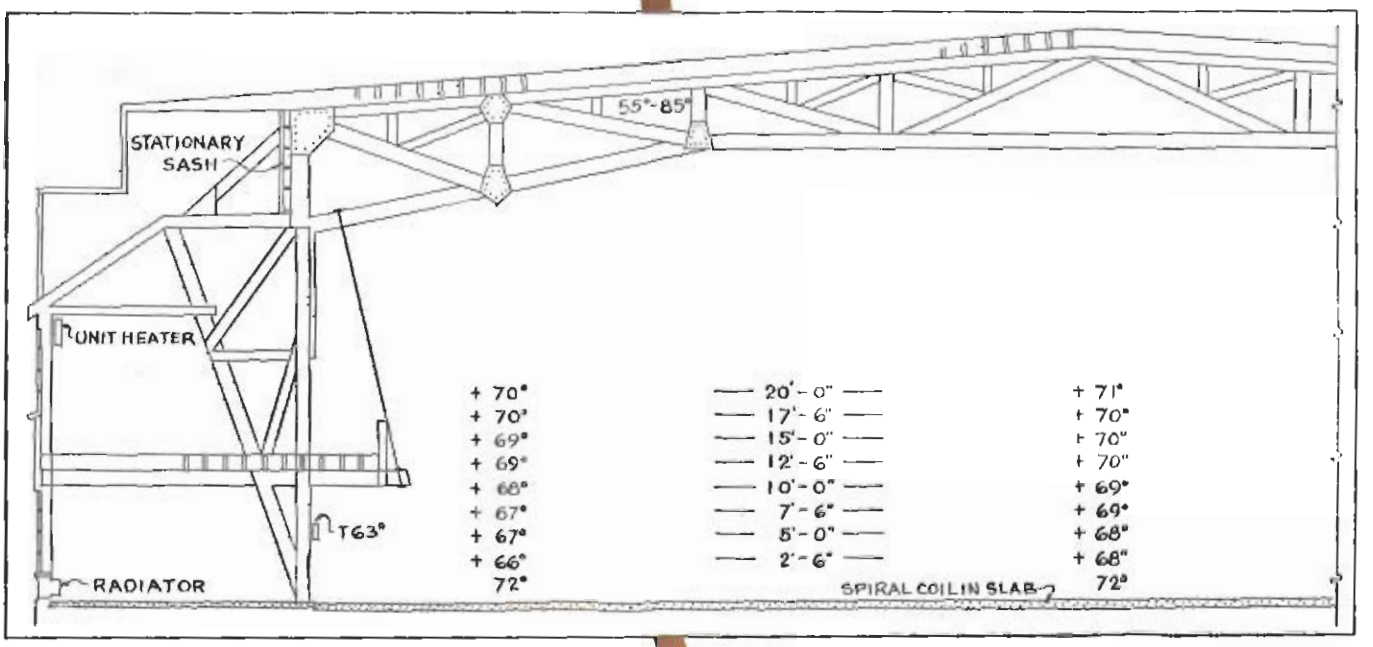
Stratification, or layering of the air is generally very much less than for conventional installations, the differences in temperature between the levels of air near the floor, at various intermediate heights and that adjoining the ceiling usually being of the order of from 2 degrees to perhaps 6 degrees or 7 degrees Fahrenheit maximum, as contrasted with variations between floor and ceiling layer temperatures for conventional installations of normally from 5 degrees to 20 degrees and not infrequently as much as 30 degrees or sometimes even more where the ceilings of the room are high.



Temperatures at three points in room with Radiant Heating Wall Panel



Temperatures at three points in room with Radiant Heating Floor Panel



Above—Typical cross section of an aeroplane hangar showing temperatures at various points above the floor during the winter.

GENERATION OF HUMAN HEAT

Normal human beings enjoying good health generate about 500 BTU* of heat every sixty minutes. Only about 100 of these units are required for internal energy. The remaining 400 units must be dissipated if the balance is to become normal. If more is lost the human being has a cold sensation, if less he becomes too warm.

Benefits derived from the usually lower and more even temperature, and from the cleaner and more sanitary atmosphere resulting from the absence of drafts and eddying air currents are far reaching. Persons who live in homes warmed by Radiant heat have fewer colds during winter.

Physicians who have made a study of the benefits of Radiant Heating are most enthusiastic about it from a health standpoint. It is for this reason that many physicians in building new homes for themselves are insisting on the Radiation type of heating systems. It is also the reason why such systems are being used in additions to hospitals or for heating new hospitals under construction.

* BTU: British Thermal Unit, the quantity of heat necessary to raise the temperature of a pound of water one degree Fahrenheit.

COOLING SYSTEMS FOR SUMMER

The same tube layout which is used for Radiant Heating in winter can be used without change for cooling in summer where humidity is not too high and cooling is not carried out below the dewpoint by merely circulating cold water through it instead of hot water or steam. A number of present Radiant Heating systems are used during the summer for cooling with satisfactory results. This is especially true in states which do not have many torrid days where the temperature and humidity are high.

In addition to the merits of Radiant Heating which have been mentioned one that impresses housewives, and in fact all members of the family, is cleanliness. Dust particles do not adhere to warmed surfaces. Because there is less dirt blown about, the draperies, walls and ceilings do not require constant cleaning to keep the home bright and clean. Neither does the interior of the home require costly redecorating so often. Because of the greater evenness of temperatures and the absence of hot blasts or concentrated heat, the cracking of plaster and woodwork, and the loosening of joints in wooden furniture are appreciably reduced.

NO LOST HEAT WITH HIGH CEILINGS

In Radiant Heating, the rooms, particularly where the heating coils are embedded in the floor, and even where the floors are embedded in concrete or paved with flagstones, the feet are comfortably warm while the head remains cool, a condition which since ancient Egyptian and Babylonian times has been recognized as a first requisite of health. A warm head and cool feet have always spelled ill-

ness. Of particular importance in structures with high ceilings and large working spaces to be heated is that the effect of heat radiation from a Radiant Heating system installed in the floor extends evenly throughout the space to be heated. Most of the heat is not wasted by being convected to the higher levels where it is not needed.

This installation is also indicative of the remarkable evenness of the temperatures over a sufficient height above the floor adequately to serve the working space. Test figures obtained during a continuous heating period from November 1, 1942 to May 15, 1943 – at which time heat was discontinued – for four United States Army Airplane Hangars (see diagram on page 6) equipped with the floor-coil type of Radiant Heating by Elmo Hall, consulting engineer of Denver, give the following operating data for this zone:

Outside Temp. °F.	Flow Temp. °F.	Return Temp. °F.	Equivalent Steam Radiation Sq. Ft.	Slab Temp. °F.
50	90	84	1370	72
35	101	90	2730	72
15	112	96	3760	71
−10	122	98	5800	70
−17	130	101	6960	70
−30*	140	103	8480	68

* Four hours only.

Mr. Hall has reported that this installation came through the heating season in a highly gratifying manner. He pronounced it a success. The lack of air motion, he said, was a contributing factor to the comfort of those men working in this hangar. An executive of a large air line expressed amazement on seeing these people working on a fuselage 16 feet above the floor, on the wings, on step ladders and sitting on the floor, all working in the same degree of shirt sleeve comfort.

Another aspect of this evenness of temperature with Radiant Heating systems, which is of particular importance in its application to industrial space heating installations is that of heat recovery after a sudden drop in temperature such as is caused by the opening of doors for the passing in or out of vehicles. Mr. Hall points out that during one of the tests at 10 degrees outside, with the wind at 20 miles an hour, the thermometer in the center dropped 22 degrees when the doors were opened to admit a plane, recovering their original reading in less than six minutes after closure. This is due to the fact that the principal source of heat is by direct radiation rather than by heating the air mass.

OPERATING COSTS ARE REDUCED

The operating costs of a Radiant Heating system are substantially less than those of a conventional installation providing a comparable degree of comfort, the savings ranging from 20 to 33-1/3 percent. Mr. Ralph Pomerance of Pomerance & Breines, architects, New York, installed a Radiant Heating system in his home at Cos Cob, Connecticut. He said the initial cost of an installation was about 20 percent more than a conventional system. The annual operating costs are about 33-1/3 percent less and it is expected to absorb the greater initial outlay in fuel savings in about four years.

The firm of Pomerance & Breines, like many other leading architectural firms throughout the country, is enthusiastic about Copper tube for Radiant Heating systems. As a result of this firm's experience it favors ceiling panels. Mr. Breines states that one

Below—In the State of California a number of swimming pools have been equipped with Radiant Heat to permit year around bathing.

of the most important considerations in designing efficient Radiant Heating systems is to make provision for complete reflective insulation. This includes air-tight construction and he prefers metal foil for the insulation so as to eliminate all infiltration of air. This foil, he says, reflects heat rays and will not absorb heat as will some of the other types of insulation materials. His firm recommends Copper tube for many reasons, one of which is the fact that it can be used in smaller diameters, another is the ease of fabrication on the job. This firm designed a Radiant Heating system at the Nurses' Residence and School for the Harlem Hospital, New York. The firm also specified Copper tube for the heating system in a group of 16 homes, built on a cooperative basis at Yonkers, New York and for many other homes. Before World War II the firm installed a Radiant Heating system in the seaman's Hiring Hall, National Maritime Union, Philadelphia, Pa.

REASON FOR LOWER OPERATING COSTS

There are a number of reasons for the lower operating cost of Radiant Heating systems. The principal three are: (1) The lower temperature gradient between inside and outside atmosphere resulting from the absence of the superheated upper strata characteristic of conventionally heated spaces and from the generally lower room temperature necessary for comfort; (2) The temperature of the water circulating through the coils of most Radiant Heating systems will rarely exceed 130 degrees maximum; it normally varies from 85 degrees or 90 degrees to perhaps 110 degrees or sometimes 120 degrees which temperatures are much less than for the great majority of conventional hot water systems; (3) The heat radiations in a Radiant Heating system, like the light rays of a good general lighting system, cannot be permitted to be absorbed by their surroundings or scattered in directions where the radiations are not needed; for this reason effective use has been made in practically all the Radiant Heating systems of heavy layers of insulation like metal foil and other materials which insulate and reflect or deflect the heat waves into the proper direction while reducing their absorption to an irreducible minimum.

COST OF INSTALLATION

While Radiant Heating installations generally have an initial cost moderately higher than the conventional heating systems, the saving in fuel within a few years will generally more than offset the extra initial outlay of the installation.

Raymond Viner Hall, an ardent disciple and able follower of Frank Lloyd Wright, has emulated him also in the use of Radiant Heating. In fact he has used this system for most of the houses for which he has furnished the designs or which have been constructed under his direction. Writing in a plumbing and heating magazine, Mr. Hall gave a summary of the cost of several Radiant Heating installations in relation to the whole cost of the home. This percentage ranged from 6.8 to the high of 9.6. Following is his table of the costs of such installations in moderate cost homes, all having hot water excepting "B" which has steam:

Job	*Total Cost*	*Radiant Heating*	*Percentage*	*Fuel*
A	$5,200	$495	9.5	gas
B	5,200	375	7.2	coal
C	6,500	525	8.1	gas
D	7,000	675	9.6	oil
E	8,500	575	6.8	gas

RADIANT HEATING ON PACIFIC COAST

Mr. Robert Bruen of Oakland, California, who has been mentioned previously, has made scores of Radiant Heating installations, utilizing copper tube, in all types of construction. These installations include all three locations for the heating coils, that is in floors, usually cement, in plastered walls, and in plastered ceilings. He finds that the coefficient of expansion of copper as compared to that of the materials in which the tube is embedded is sufficiently similar to avoid any troubles from differential expansion and contraction. Moreover, copper tube is readily shaped into the required coils or loops on the job.

In addition to using flexible Copper tube with soldered fittings in Radiant Heating installations in scores of homes on the West Coast, Mr. Bruen has also made installations in hospitals, apartment houses, factories, schools, greenhouses and even in swimming pools. In some of his installations Mr. Bruen has successfully used a novel prefabricated expanded metal panel with Copper coils, which he has patented. It is now standardized on ¼" and ⅜" nominal size tube. The delivery of the panel sections to the job requires only simple connections to complete the installation of the system. These panels are factory tested and the heating contractor has only to have his skilled mechanics join the panels and connect them to the hot water system as the house is under construction.

RADIANT HEATING IN THE EAST

While the majority of Copper tube Radiant Heating installations in homes prior to World War II were on the West Coast, thousands of such installations are now being made on the Atlantic Seaboard and in other sections of the country. The few that were installed in new homes built in the East before Pearl Harbor have given most satisfactory service. In addition to Radiant Heating in homes many others are being made in hospitals, schools, factories and other types of construction.

Among the first installations of Copper tube for Radiant Heating in the East was a home constructed at Wexford, Pa. by William J. Kerr from a design made by Raymond Viner Hall. This installation was made when the house was completed during the early part of 1940. The house has a floor-type system. Hard drawn Copper tube with soldered U-bends was embedded in the floor. The sinuous Copper coils of 2" tube were spaced 2 feet apart on centers, except for the section nearest the outside wall and where the hot water from the boiler enters the coils, where the coils are on one foot centers. To meet the great heat losses of the large glass area of the living room front the ends of the outermost floor-tube are tapped to feed a coil against the wall for the full length behind the low book cases. Holes spaced 6" apart in the top of the book cases permit the heat to rise against the wall for the full length behind the low book cases.

COILS LAID ON BED OF GRAVEL

The floor coils were laid on a heavy bed of gravel on broken stones. The spaces between the tubes were filled with gravel until only the tops of the tubes were exposed. A small Agulux boiler fired by a St. Johnson Company gun-type burner furnishes the hot water. It has a Minneapolis-Honeywell Stack Control, and the oil burner is controlled by a water thermostat set by the owner according to the season from 150 degrees to as high as 210 degrees. Circulation of the hot water is through the coils secured by a ½-HP motor-driven circulator actuated by a M-H room thermostat. The latter is mounted on a wall between the kitchen and bedroom, about 5' above the floor. This installation, like others, has proved highly satisfactory, particularly during the most severe winter conditions. Since the installation was completed the mercury has often fallen below the zero mark and there have been some very severe sleet and snowstorms.

Above—Boards of Education throughout the country have found Copper tube a satisfactory material for Radiant Heating installations.

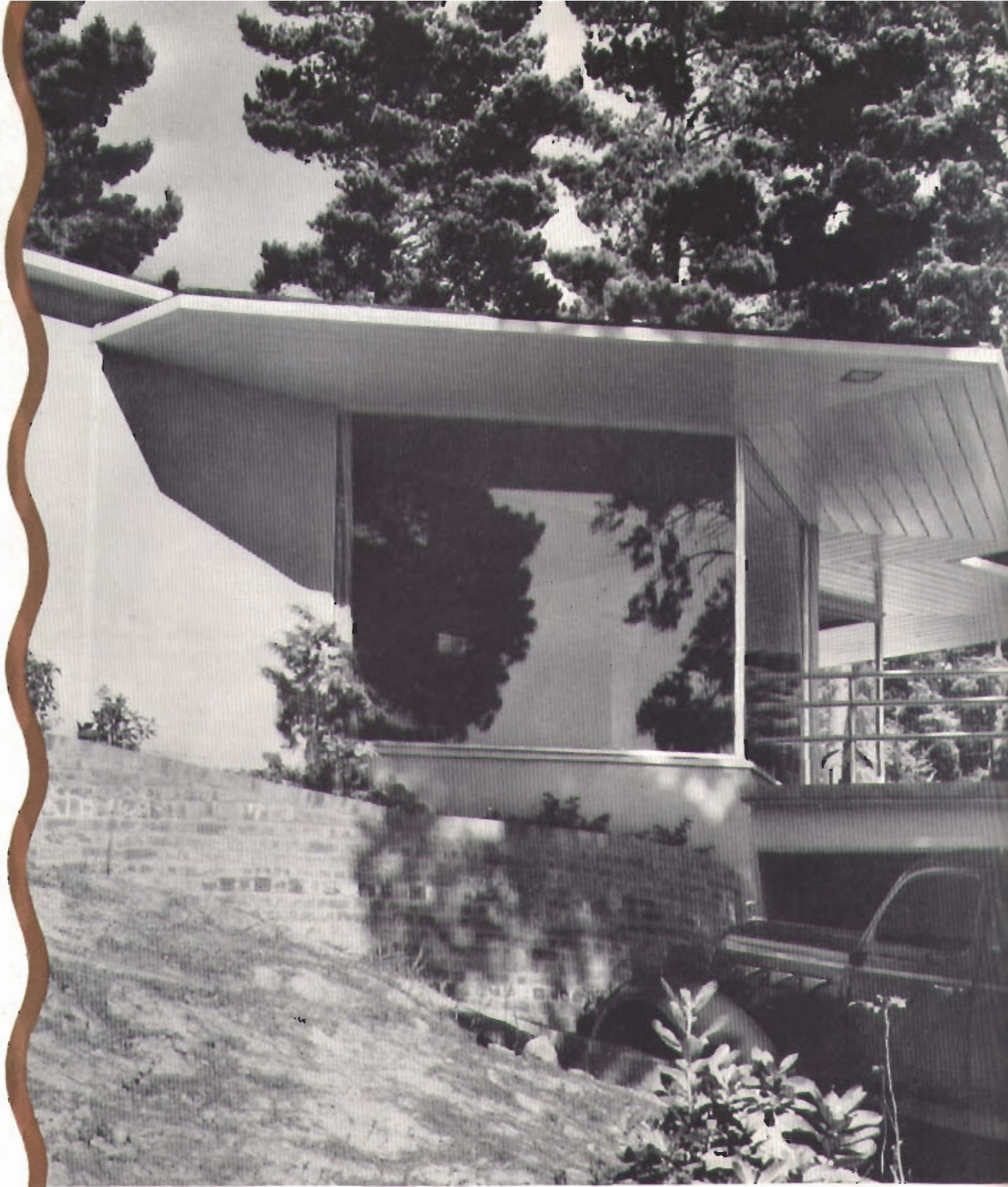
The cost of this home approximated $5,000 while the Copper tube Radiant Heating installation amounted to about $450. The annual heating costs, according to the owner, amounts to less than if any other type of heating was used.

FOR MANSION OR COTTAGE

Radiant Heating installations are suitable for mansion or cottage. William B. Freeman of Reliez Station Road, Contra Costa County, California, has an installation in his magnificent new home. This installation was made by Robert Bruen & Son. The system consists of sinuous Copper coils embedded under the quarry tile floors. There is a 50,000 gallon swimming pool on the estate. The water is heated during the winter months by a system of coils illustrated later in this book. The family and guests can use the pool 12 months in the year. The house, swimming pool and landscaping were completed at a cost of nearly $250,000.

The use of Copper flexible tube for Radiant Heating is just as satisfactory and as economical in a small house or cottage. In fact thousands of

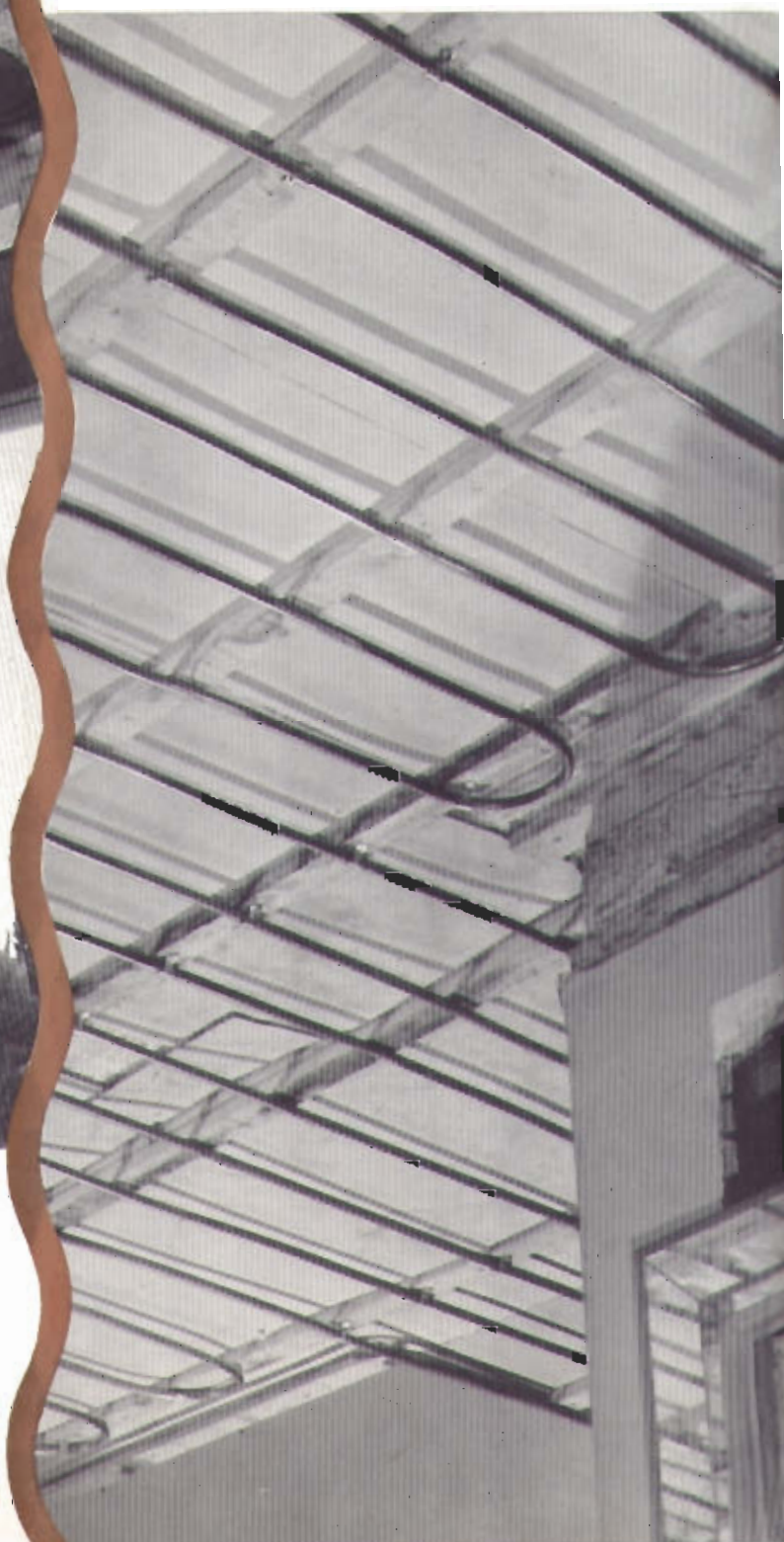
(Please turn to page 19)



Above—Residence of E. A. Smith, Oakland, California. The Radiant Heating system was installed by Robert Bruen & Son, also of Oakland. This is a floor installation with 4-inches of concrete poured on the ground, then a sand covering over the tube with concrete slab top.

Below—The study of the Smith residence showing a modernistic setting which provides more room and comfort for the family. During the winter months in Northern California which are sometimes severe the home is heated with hot water through Copper coils at little expense.

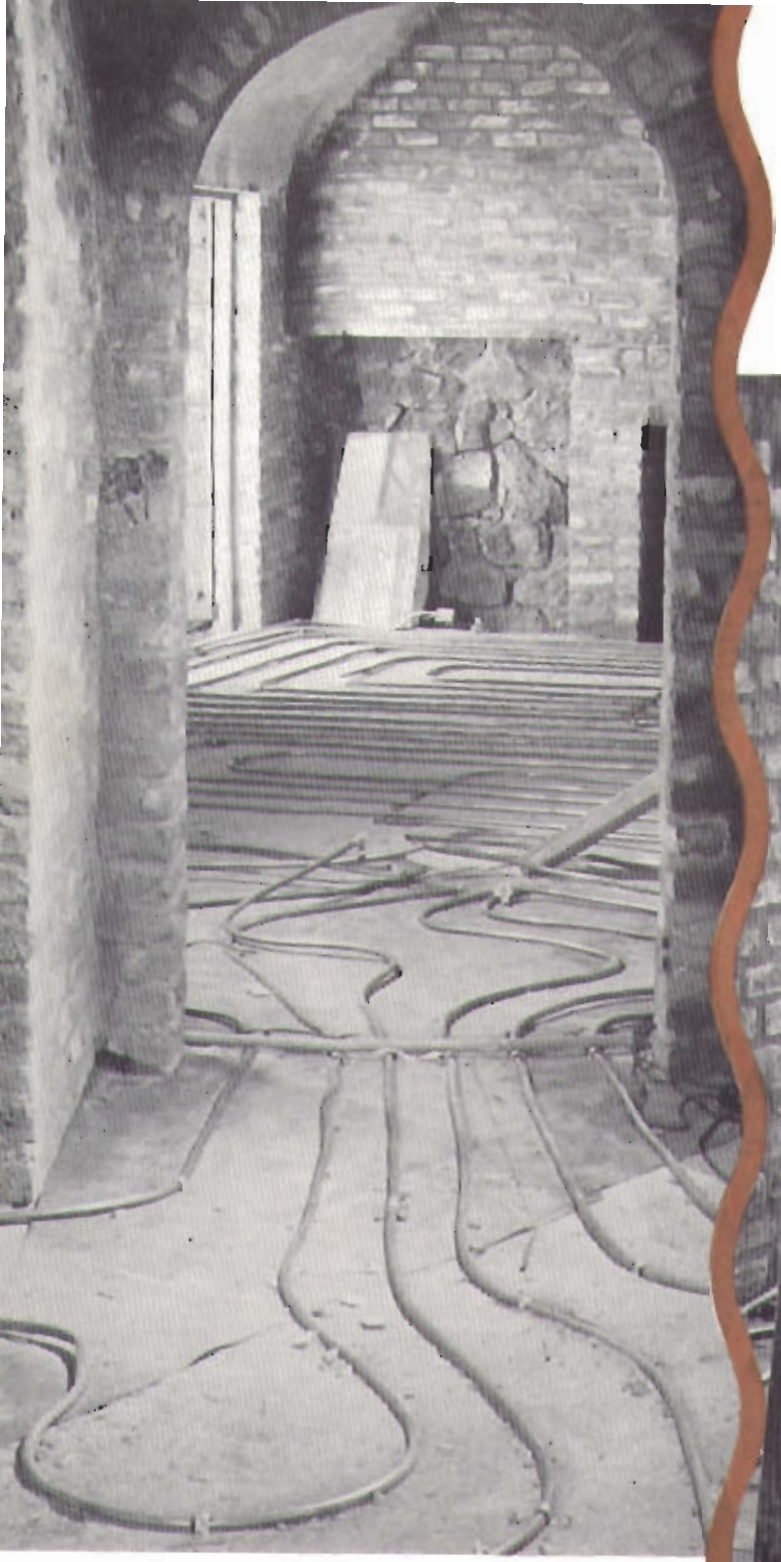
Left—Large residence in Piedmont Pines at Oakland, Calif. with a gorgeous vista overlooking San Francisco Bay, is heated by a Copper tube panel heating installation. These Copper coils are prefabricated by Robert Bruen & Son of Oakland, Calif. under the name of Thermapanels, and are available to heating engineers and contractors.



Right—Ceiling paneling of soft Copper tube was used in the residence of Harold G. Stiers of St. Louis, Mo. After the Copper tube was in place it was covered with plaster. The savings in fuel bills in three or four winters will more than pay for the slightly higher cost of a radiant panel heating system, especially where the winters are severe.

Right—Residence of H. H. Eggleston of Piedmont, California, which had a Copper tube Radiant Heating system installed by Robert Bruen & Son when the building was built several years ago. Copper tube was laid in a spiral arrangement with a cold asphalt filler between two slabs of concrete. Soft Copper tube was used for ease of installation.

Left—A room in the Eggleston residence portraying the saving of space in homes which are equipped with Copper tube for Radiant Heating. Large windows are possible which give beautiful views of the countryside while during the winter months when snow falls and the temperature is close to zero the home is easily kept comfortable.

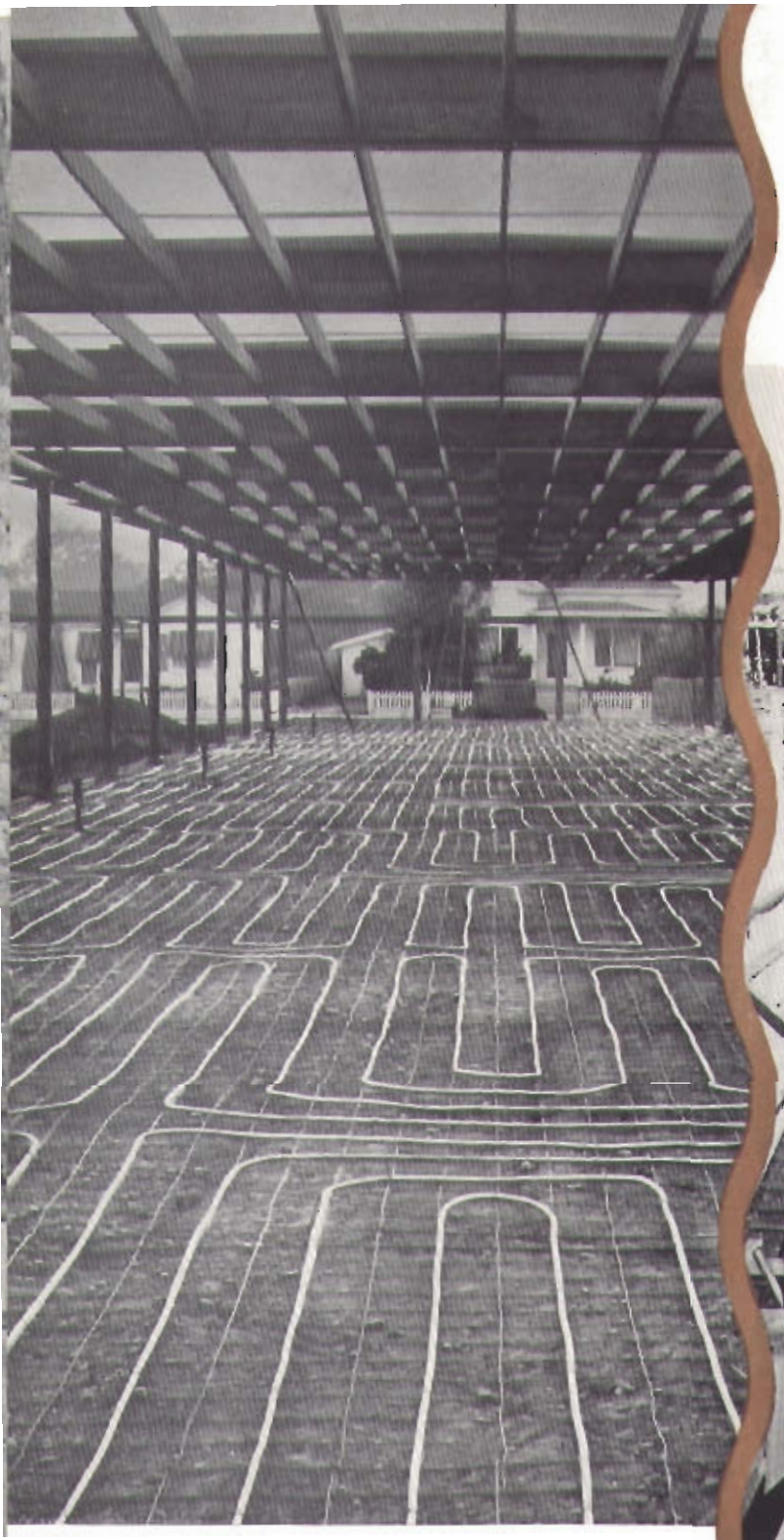


Left—Copper tube can be snaked around the floors of a home with ease as depicted in this residence when it was under construction. It is the home of J. J. Rosebrook of Alamo, California. The installation was made some time ago by Robert Bruen & Son of Oakland. During the winter months the home is heated with a very small expenditure.

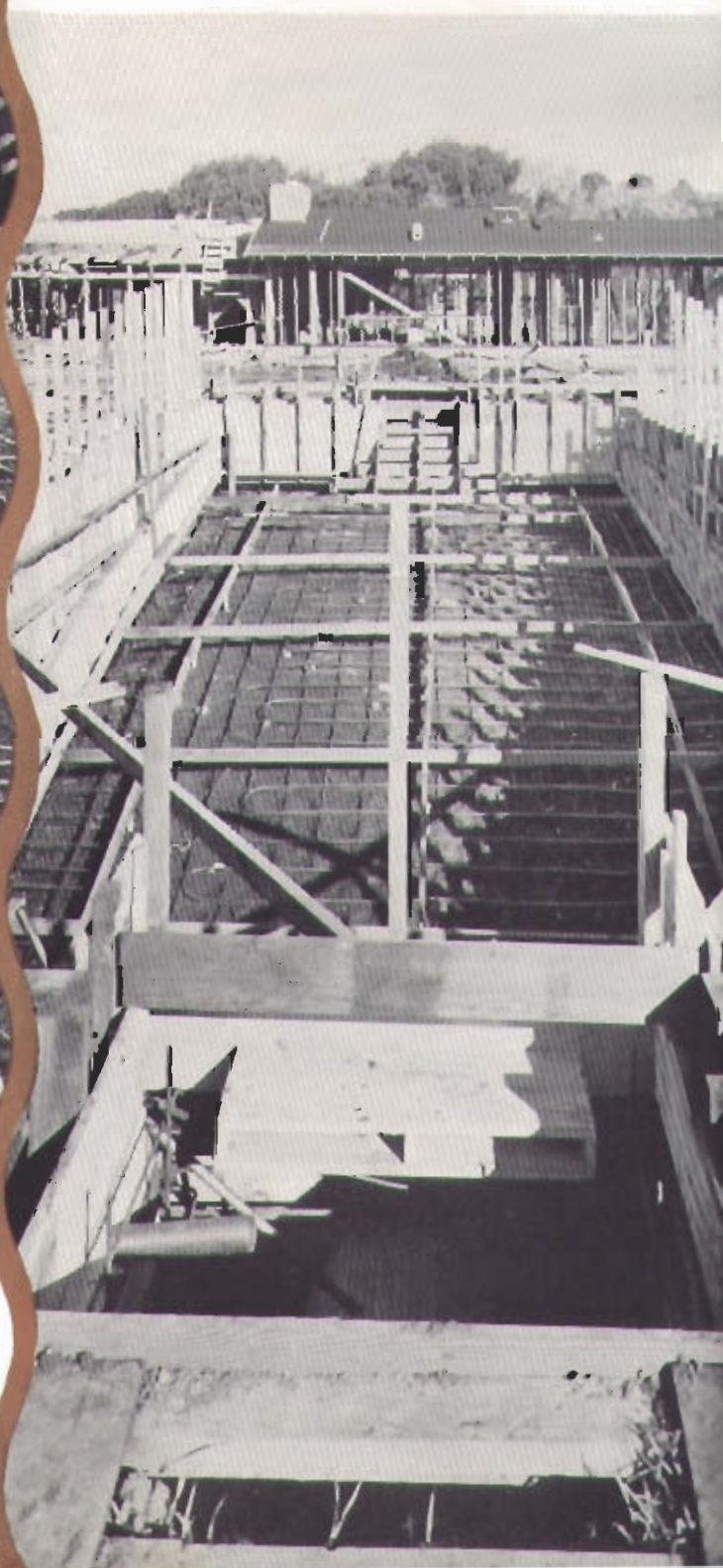
Right—Another view during the installation of flexible Copper tube in the Rosebrook residence. The home has now been occupied for several years and the installation, like all other Bruen jobs, has given most satisfactory results. This home overlooks mountains and valleys where weather conditions are most severe with frequent heavy snows.

Right—Prefabricated Copper ceiling panels in the home of William J. Besler of Happy Valley, California. This system is a Bruen patent and gives most satisfactory service. Many such installations have been made on the West Coast. In Radiant Heating installations some architects and owners prefer ceiling panels to coils laid on the floor.

Left—Copper prefabricated panels applied against old plaster in a small apartment building being remodeled. In the remodeling of many apartment houses, homes and other type structures the owners are changing to the use of Radiant Heating because they find it satisfactory during the winter months and economical to operate.

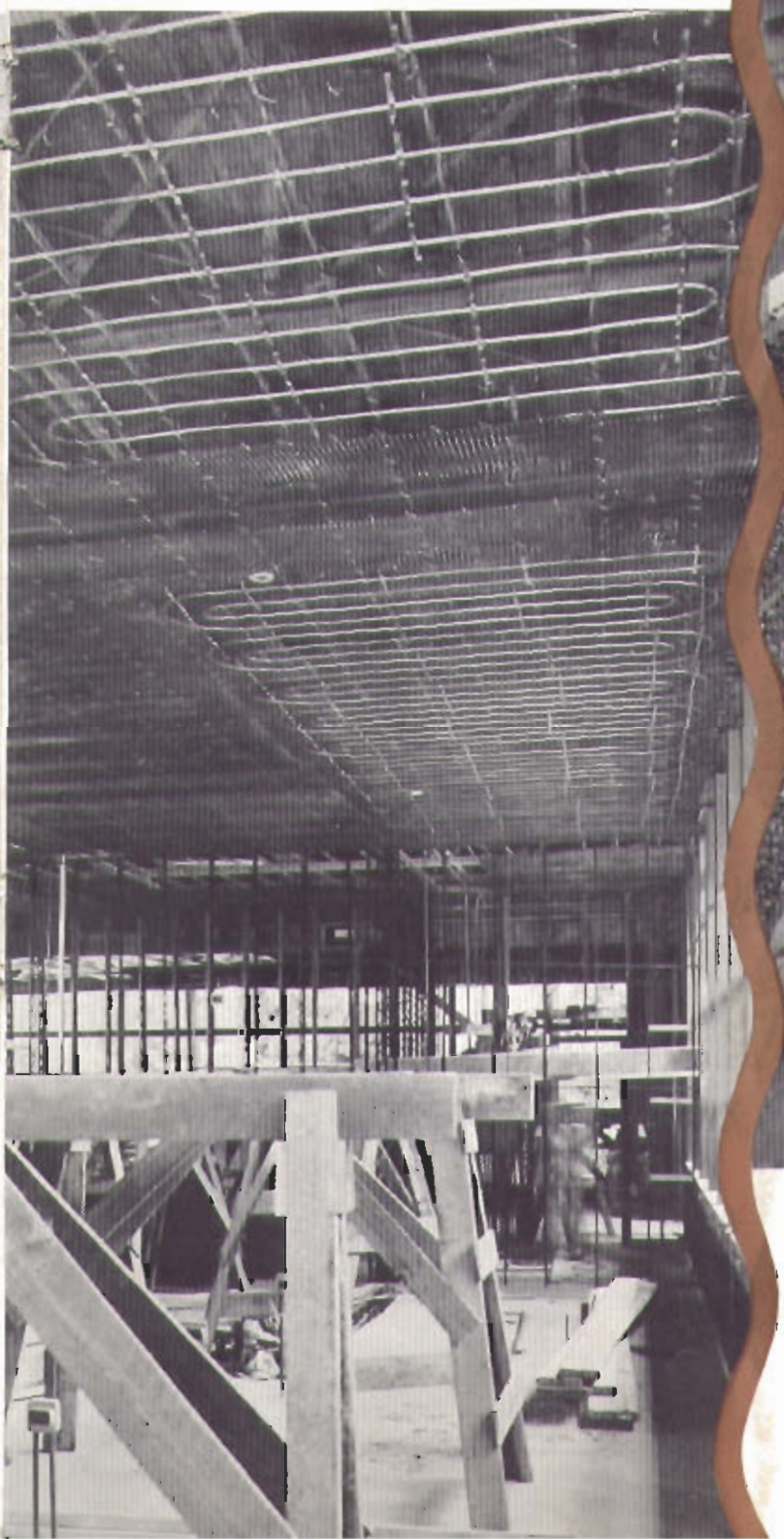


Left—View of an installation of Soft Copper tube for the Radiant Heating system of an elementary school. In many new public schools, high schools and colleges this type of heating is being installed just as it is in homes from coast to coast and from Canada to the Gulf. Copper is a superior metal for such installations.

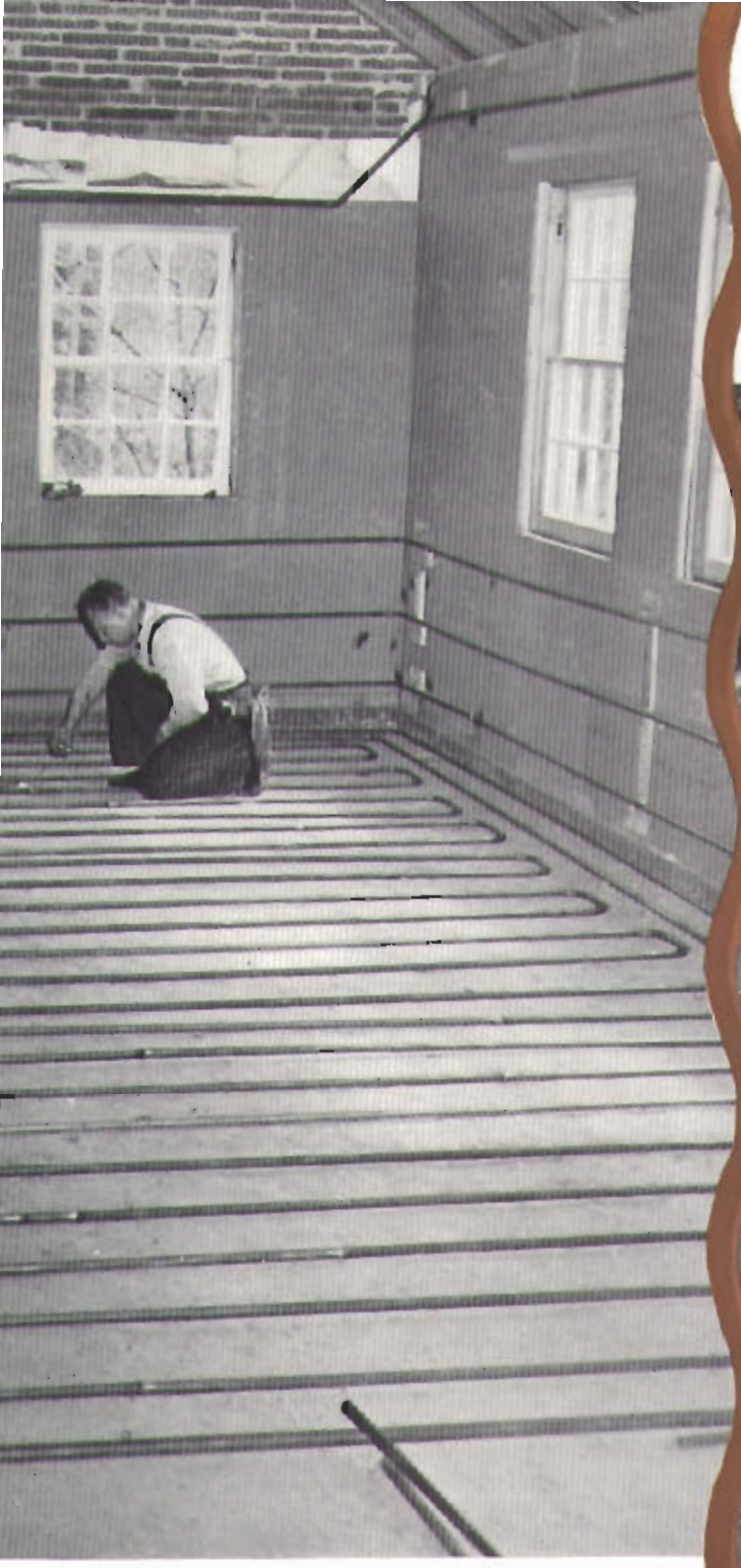


Right—This scene shows the installation of Copper tube for Radiant Heating in a 50,000 gallon swimming pool on the estate of W. B. Freeman, Relíez Station Road, Calif. The home in the background also shown under construction is completely Radiant heated by means of sinuous Copper coils embedded in the ground under quarry tile floors.

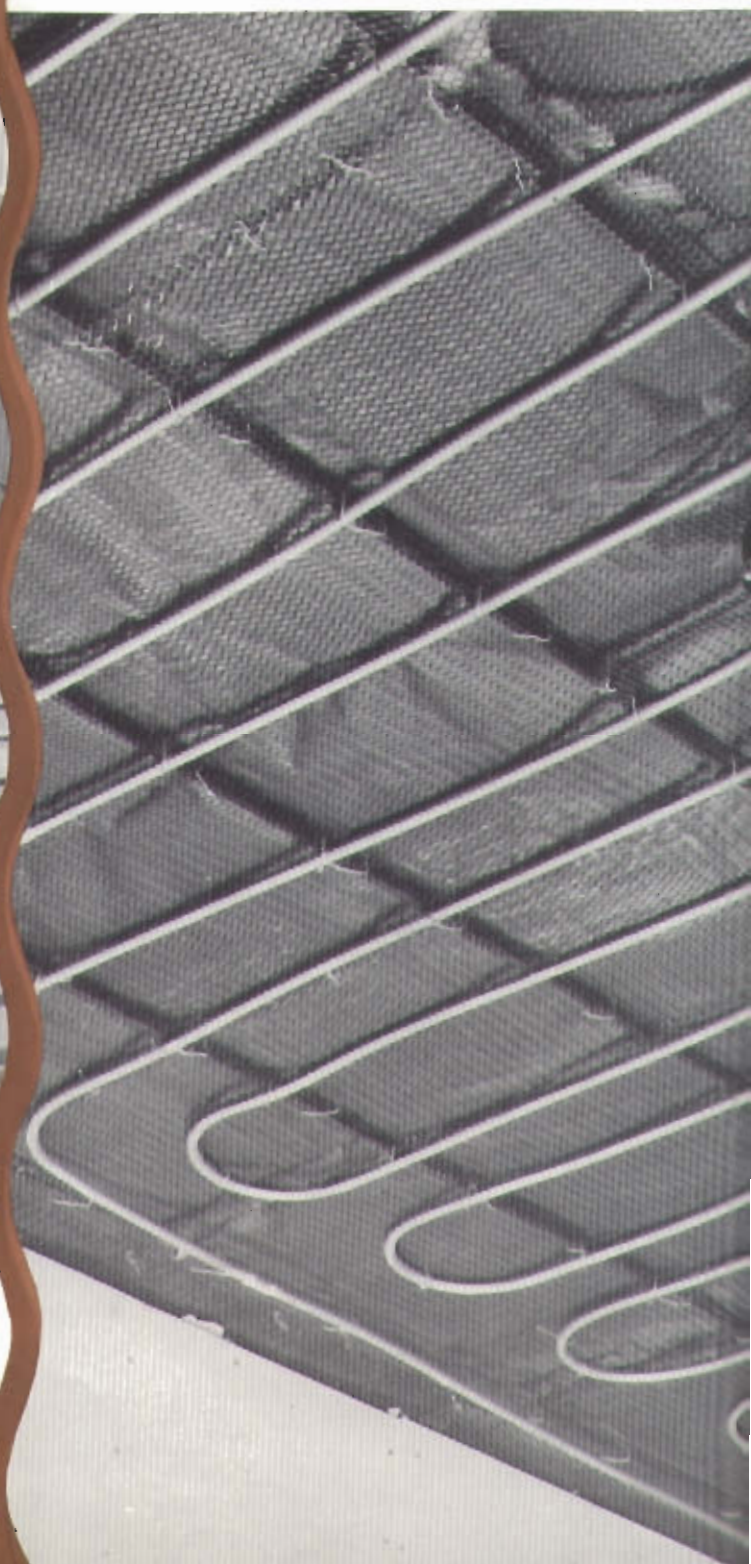
Right—Greenhouses are kept heated best with Radiant Heating systems. This Greenhouse is owned by Dr. H. J. Kolb of Piedmont, California. He has two such Greenhouses while his home is heated with Bruen patented prefabricated panels embedded in the plastered ceiling. Copper panels were also used in a Hollywood beauty salon.



Left—Six new Science Buildings for Mills College at Oakland, Calif. have been equipped with radiant panel heating, using Copper tube in the prefabricated form of Thermopanels, made by Robert Bruen & Son at Oakland, Calif. This photograph shows a classroom with the Thermopanels metal lathing in place ready for plastering.



Left—Installation of Copper tube radiant heating panels in the home of Herbert Mirschel at Hempstead, N. Y. on Long Island. A noteworthy feature of the design is the fact that the Copper floor panels are supplemented by Copper wall panels. Since completion the owner has expressed complete satisfaction with this system.



Right—Copper tube panels in a ceiling installation in the Denwal Building of St. Charles, Mo. Three-eighths inch, Type L Copper tube, spaced seven inches on center, were attached with wiring to the metal lath. Four inches of rock wool insulation was laid over the metal lath above the panels of Copper tube which were covered with plaster.

homes to be constructed under FHA guaranteed loans for veterans of World War II will have such heating installations. Some of these homes will be prefabricated houses. There have been a great number of such developments already constructed for our servicemen throughout the land.

HOME AT HEMPSTEAD, LONG ISLAND

An example of the use of flexible Copper tube for Radiant Heating in a house costing in the upper brackets is in the home owned by Mr. Herbert Mirschel, President of the Mirschel Lumber & Supply Corporation of Hempstead, L. I., New York. It is a long rambling brick structure. The coils are embedded in the floor with proper insulation and the owner and his family are most enthusiastic about this type of heating.

When M. G. Duncan, an architect designed the plans for his home at Hamden, Conn., he included Copper tube for Radiant Heating. The coils are ⅜ inch of soft Copper tube. The tubes are in the floor supplemented by ceiling panels in the living room and in the bathroom. An automatic oil fired burner is used. The fuel bill approximated $8.50 a month during the winters of 1941-1945. During many of the winter months of those years the mercury was around the zero mark with occasional heavy snows.

TESTS OF SOLDERED JOINTS

The Federal Housing Administration inaugurated a number of tests at the Bureau of Standards, Washington, in 1936 on the strength of soft-soldered joints in Copper tube. These tests were continued at the Bureau after 1937 under the sponsorship of the Copper & Brass Research Association and Committee A-40 of the American Standards Association, resulting in standards for the present solder fitting joints for Copper tube. These tests are recognized by all industries concerned as governing maximum service pressures for soft soldered joints in Copper tube made with a 50 tin, 50 lead solder for use at temperatures not exceeding 250 degrees. The maximum service pressures are based on long-time tests in which various test pressures were sustained for many thousands of hours, until at last failure occurred as a result of creepage. These maximum long-time sustained tensile load tests were found to be far more conclusive than those of short-time tensile tests in which the stresses are increased at such a rate that rupture takes place in a matter of minutes rather than many months of sustained stresses on the joints.

PRESSURE RATINGS FOR JOINTS

If properly installed the internal walls of a Copper tube installation for Radiant Heating system are silky-smooth from one end to the other. The internal smoothness of the tube is not marred or destroyed by the presence of periodic joints. In pipe however, each screw type fitting unavoidably means a local discontinuity of the pipe's inner lining or surface which sets up more or less serious eddies and thus adds to the pipe's internal friction against flow; although probably not altogether absent, this cause of added friction in tubes with flared type expansion fittings has been reduced very substantially by careful design.

Following is a pressure rating table for joints made with 50-50 tin lead solder (ASTM):

SERVICE PRESSURE RATINGS AT TEMPERATURES FROM 100° to 250° F.

SERVICE TEMPERATURES	FLUIDS OTHER THAN STEAM		STEAM
	Nominal sizes, 2 in. and smaller	Nominal sizes, 2½ in. and larger	Nominal sizes, all
°F.	Lb./In.² (gauge)	Lb./In.² (gauge)	Lb./In.² (gauge)
100	175	150	—
150	125	100	—
200	100	75	—
250	75	50	15

A wooden form, or mold, is quickly constructed, in sections easily moved from job to job. The workman, with a section of coiled soft copper tube starts the simple operation.

CONSULT YOUR ARCHITECT

When you are planning to build your home consult your architect regarding Radiant Heating particularly with the use of Copper tube. You will find him enthusiastic about this type of heating. Many architects in designing their own homes prefer it to other systems. Your heating engineer who designs the system will also be enthusiastic and will tell you it will give long and satisfactory service.

While Radiant Heating is not a complex system and can be installed at a relatively small expenditure as has already been shown, it requires competent supervision for satisfactory and economical results. Research and experience are rapidly adding to the information available to architects and engineers to assure such results. Copper tube is eminently desirable for such installations but here again, while such tube is readily shaped and connected in this use, best results are obtained only when the skill and experience available in the heating and plumbing trades are utilized.

The Federal Housing Administration, which approves loans on homes only where equipment and materials are used that have given satisfactory service over the years, approves specifications including Copper tube for Radiant Heating.

PERMITS MANY INNOVATIONS

Most architects are enthusiastic about Radiant Heating because it enables them to make many interesting and sometimes radical changes from the ordinary conventional arrangements, in their plans for new homes. The most important of these, of course, is the provision of more clear space without increasing the dimensions of the room. There is no obstruction in the way to interfere with large window areas, as the heating system is embedded in the structure. As the system is also out of sight, there is no interference with decorative effects. There is more freedom for the arrangement of furniture and hangings, with less attention necessary to future maintenance as there is less infiltration and circulation of dirt. With the danger of ugly streaking of walls eliminated, brighter colors can be used without requiring frequent washing and repainting. No warm blasts or overheated areas have to be anticipated in planning the arrangement of furniture in the room.

HEATING FOR SIDEWALKS

A unique use of Copper tube for heating similar to its use for Radiant Heating but dependent for its effect not on radiant but rather on conducted heat, is that of placing it under the sidewalks and circulating steam or hot water through it to melt snow during severe storms in Northern parts of the country. There have been a number of such installations in the East, especially along the seaboard. The Copper tube is connected to the heating system of the home and can be turned on or off easily. When a heavy snow falls the heat is turned on and the snow melts as fast as it falls with the result that it is not necessary to dig out the snow and ice from the home to the curb or from the garage entrance to the curb. This has eliminated the difficulty of driving the car in and out of the garage during a heavy snowfall. Many suburban residents have found it an almost impossible problem to drive the car from the garage when a heavy snow has fallen during the night. Heated driveways solve this problem. The installation of such a system when new or replaced sidewalks are laid is not expensive. The operating cost is relatively small, for it is only necessary to have the walks and drive heated while the snowfall is heavy.

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