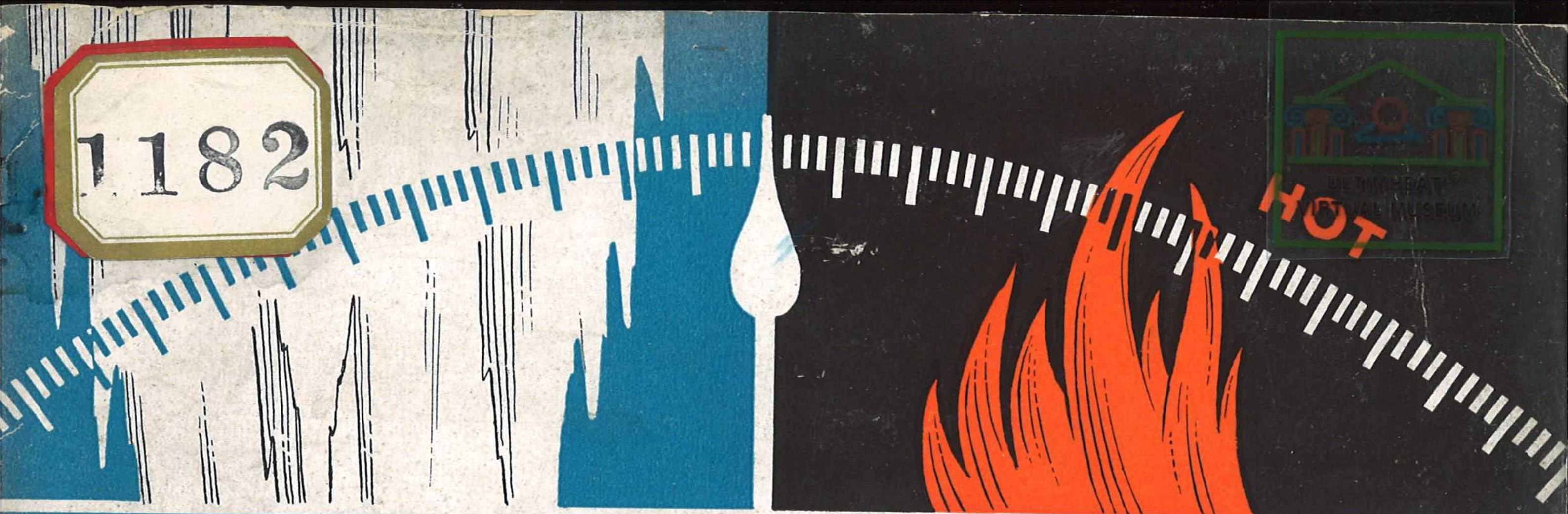
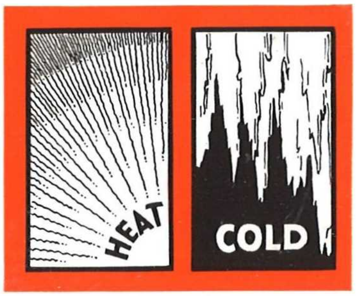


Thermostatic BIMETAL

W. M. CHACE VALVE CO. DETROIT, MICHIGAN

Interesting FACTS about BIMETAL



Making TEMPERATURE Operate Devices—AUTOMATICALLY!

CENTURIES ago, when artificers first began to work with metals, they discovered one of the now familiarly known laws of heat; namely, "Most substances *expand* when heated and *contract* again as they cool." This is particularly true of metals.

Early wagon and carriage makers made use of this physical characteristic to mount metal tires on wheels. Coopers also applied the principle in hooping casks. Later, others began to use metals with different co-efficients of expansion to operate dampers on stoves. Such devices, called "pyrometers," were in use over two hundred years ago.

One hundred years later, thermal elements were made by soldering together strips of platinum, gold and silver. When these were exposed to sufficient heat, a definite "bending motion" was observed to take place. Such thermal elements were then used, in a limited way, for mechanical thermometers, the bending movement actuating the pointer and indicating the rise and fall of temperature.

The cost of using gold and silver was prohibitive. Experiments began with other, cheaper metals. Combinations of brass and iron proved more favorable. Then, in 1899 Invar, which contains 36% Nickel and 64% Iron, was invented.

The invention of Invar was the result of a search for low expansive material for measuring standards and for improving the accuracy of chronometers. Its use for bimetallic action, due to its low expansion, was soon recognized and bimetal made of Invar and brass became a commercial product.

During the last fifteen years the rapid development in gas and electrically heated devices, both domestic and industrial, has opened a wide field for the use of low and high temperature control devices. For such devices Bimetal furnishes a convenient, reliable and economical material as a temperature responsive element.

Studies and achievements in the development of Bimetal have kept pace with the ever growing demand for automatic control. A multitude of commonly known products and devices which operate with heat are now automatically controlled by the practical use of Bimetal.

In the modern home we have such devices as the thermostatically controlled oil burner, the electric refrigerator, the air conditioner, the automatic electric hand iron, the waffle iron and many other automatic controlled conveniences. In industrial use, thermostatic control has been applied to gas furnaces, oil furnaces, ovens, air conditioners, etc.—all controlled by use of Bimetal.

Bimetals are now available to operate in practically all ranges of temperature up to red heat. The product or device to be controlled is first studied to determine the temperature range in which it functions. Then the proper type of Bimetal is selected to operate within that particular range.

WHAT is BIMETAL?

Thermostatic Bimetal is composed of two metals united by riveting, brazing, or welding, one metal possessing a high co-efficient of expansion and the other a low co-efficient of expansion. When exposed to heat or temperature rise, the material of high expansion properties will expand or lengthen, the other material, being of low expansive properties, will have little or no expansion. The result is a bending action. When the temperature drops, the high expansive material shrinks back to its original length and the Bimeta straightens back to its original shape. Should the same piece of Bimetal be subjected to low temperature, it would bend in the opposite direction and straighten out again with rise in temperature.

A Simplified Illustration of How Bimetal is Made . .

❶ A piece of metal of *HIGH* thermal expansion properties.

❷ A piece of metal of *LOW* thermal expansion properties.

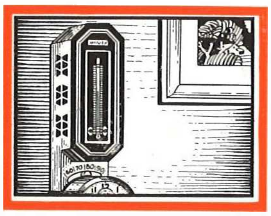
❸ Both pieces of metal are joined together. The result is: BIMETAL.

❹ When heat is applied the Bimetal *bends* to a predetermined degree. When cooled it straightens!

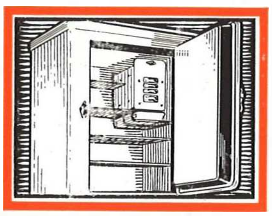
NOTE: The above is merely a simple illustration of the principle of Bimetal. It is made in many sizes, and of several different kinds of metals, and in different combinations—each best suited for the specific movement necessary to control operation of devices.

BIMETAL is widely used today as an Automatic Operating Control on products or devices where HEAT is a Factor . . .

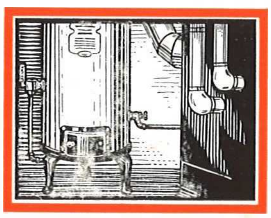
BELOW are but a few of the many automatic operation tasks that Bimetal now performs. Each year sees new products come onto the market, which are automatically operated by means of this accurate, and reliable medium.



THE ROOM THERMOSTAT CONTROLLING OIL—GAS FURNACE
This mechanism is mounted on the wall of the room to be kept at desired temperature. In the device is a piece of Bimetal which bends as the room temperature drops or rises a few degrees. In so doing, the Bimetal unit makes an "on-or-off" electrical contact for the control circuit.



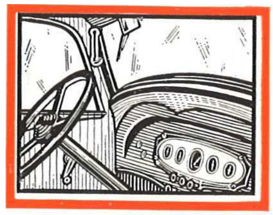
OPERATES CONTROL OF ELECTRIC REFRIGERATOR
A thermostatic device is installed in the cold chamber of refrigerator. Device contains a piece of Bimetal which bends as temperature drops or rises a few degrees in cold chamber. The resulting movements of the Bimetal, turns electric current "on-and-off."



OPERATES HOT WATER HEATER
A control is "set" to turn on gas flame when water reaches a certain low temperature and turn gas off when heated to desired temperature. The control contains a piece of Bimetal which bends, thereby operating a gas supply valve, opening and closing the valve as the Bimetal moves.

OPERATES THE AUTOMATIC ELECTRIC IRON
The automatic electric iron contains a switch which prevents iron from overheating and turns current "on-and-off" in a set temperature range without human attention. This switch contains Bimetal which bends as the iron heats or cools, thus turning current "on-and-off."

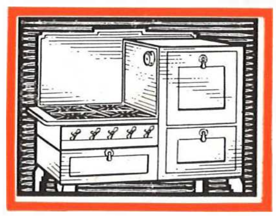
THE AUTOMOBILE
Bimetal is widely used in the American automobile to assure automatic operation of various units in the car. Common among these are the thermostatically-controlled Automatic Choke, Manifold Heat Control, and the new, high grade Electric Generators.



THE AUTOMATIC ELECTRIC WAFFLE IRON AND PERCOLATOR. The controlling element in both devices contains Bimetal. When coffee reaches boiling temperature, the Bimetal automatically turns current off, preventing the appliance from boiling dry.

THE AUTOMATIC ELECTRIC TOASTER
This thermostat, which contains Bimetal, keeps the toaster at a predetermined temperature, opening and closing the heater circuit.

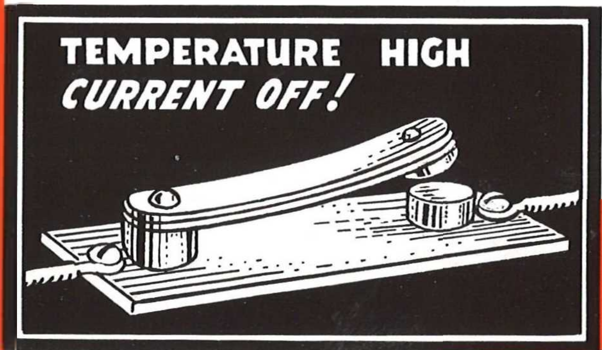
THE OVEN THERMOSTAT ON GAS AND ELECTRIC RANGES
Here, too, Bimetal operates the fuel supply and thus maintains the oven at any desired temperature range. Installed within the oven chamber, the Bimetal responds to the slightest change in temperature, and by its bending movement actuates proper fuel supply.



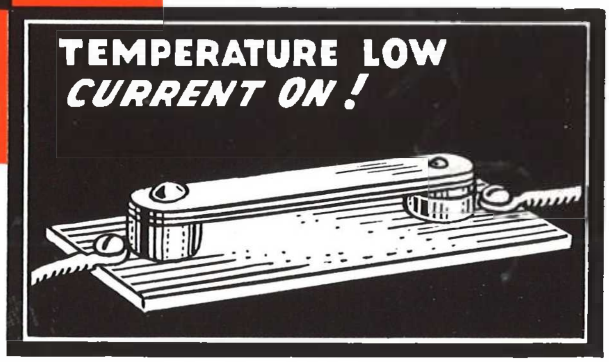
CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"

HOW Thermostatic Bimetal Operates . . .

A Simple Illustration of How Thermostatic Bimetal Operates an Electrical Contact . . Turning ON and OFF as Temperature Changes . .



This is a simplified illustration of an electric switch. The long, flat strip is a piece of Bimetal formed to retain a curved position at a predetermined temperature. The current is now OFF (contact open).



The same switch. The temperature has changed and the Bimetal has moved to a straight position, closing contacts, thus completing the circuit. The current is now ON.

CHACE Thermostatic Bimetal is now widely used by the manufacturers of a multitude of products or devices which are operated by electricity, and which are designed to function under changing temperature conditions.

Wherever temperature (high or low) is a factor, there is an opportunity to operate the product automatically by means of Thermostatic Bimetal.

Recent years have brought a tremendous advancement in the art of temperature control. With the development of various special alloys, Chace Thermostatic Bimetal has become available for temperatures up to red heat.

Each combination of two metals or special alloys when made into a bimetal element produces definitely known degrees of movement for a predetermined temperature change. It is possible, therefore, to design control devices, switches, gas supply valve mechanisms, etc., in which a bimetal unit is used for the operating part. The size of the unit depends upon the available temperature change and as to how much movement is required. Close coöperation with the product or device manufacture is desirable in order to accomplish the desired action with the selection of the proper bimetal type best suited for the application.

CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"

Made in MANY SHAPES . .

Designed to Produce a Variety of Movements . .

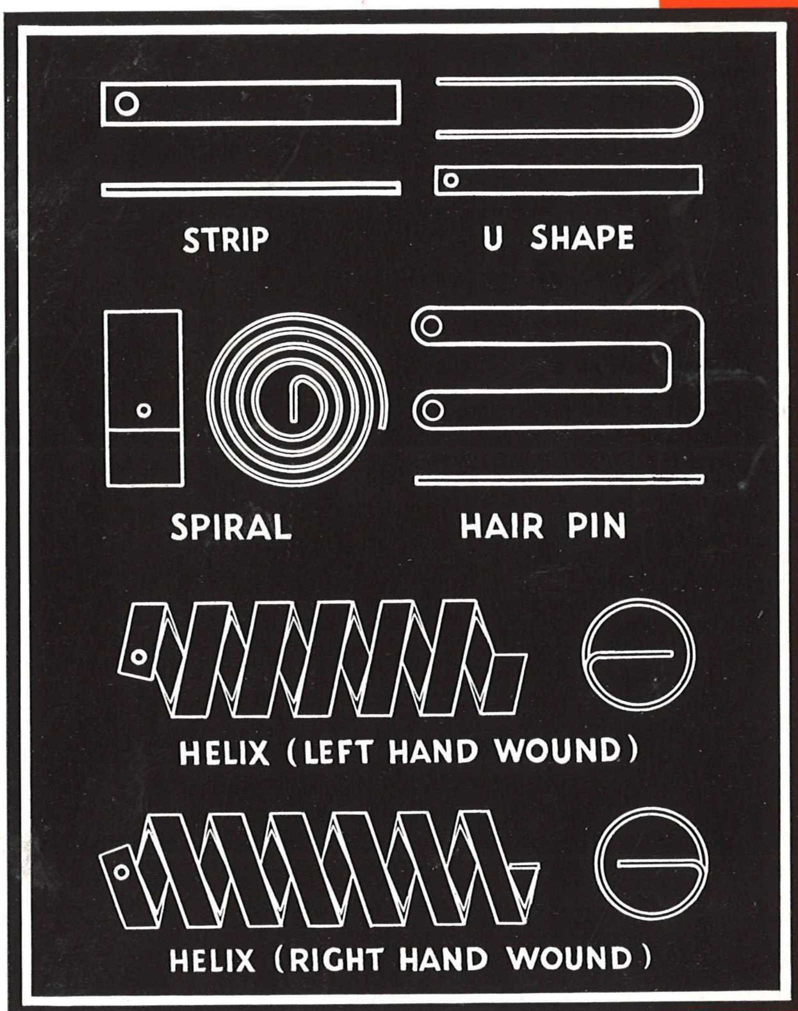
Designed to Fit Mounting Space of Devices . .

IT must not be misunderstood from the foregoing that Bimetal is only furnished in flat strips, to provide merely a "make and break" contact as simply illustrated on the preceding page.

After the two desired metals are combined, the resulting Bimetal is cut, trimmed and shaped into various forms.

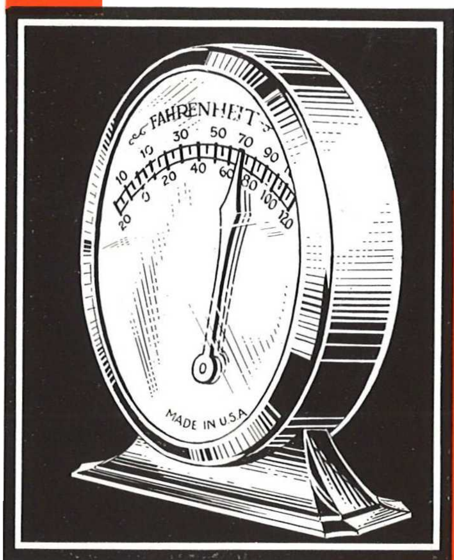
Chace Thermostatic Bimetal is furnished to the trade in sheets and strips. It is also made up and sold in special shapes to meet requirements of device in which it is used, in accordance with customers' specifications.

Chace maintains an experienced engineering department, to aid manufacturers in selecting the proper type of Bimetal. A completely equipped plant is available for shaping, forming and heat treating the special shapes, so that manufacturers may obtain them, to their specifications, ready for assembly in their products.



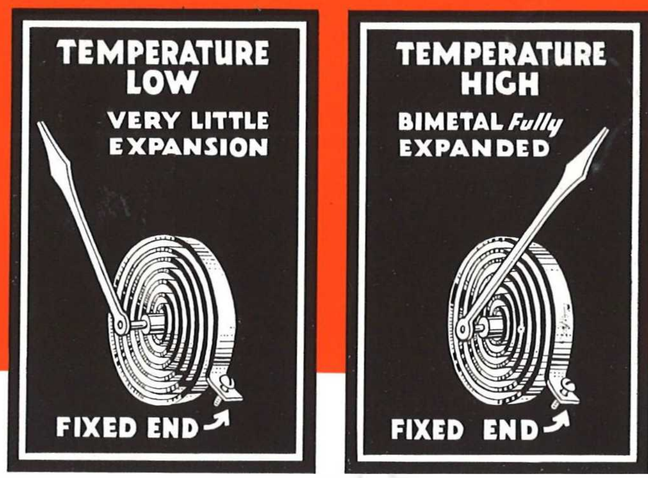
HOW the SPIRAL SHAPE Operates . . .

Using the Common Thermometer as a Simple Example . .



The Inside End of Spiral is Attached to the Free-Swinging Dial-Pointer—the Outside End of Spiral is Permanently Fixed in the Casing.

RESULT: Heat Rotates the Spiral, thus Moving the Pointer.



ON page five we illustrated but a few of the many shapes into which Bimetal is formed.

There are several important reasons for these and other different shapes. First, the completed Bimetal unit must fit neatly into the assembly of the particular operating and control device, whether it be for an oil burner, hot water heater, electric iron, etc. Thus it must be shaped to assure a practical assembly.

Next—the action caused by the bending of the Bimetal unit can be converted into an up-and-down movement, or a right-and-left movement, or into a twisting and turning movement. The *shape* of the finished Bimetal unit determines the kind of movement. The *size* and the type of metal as well as the varying degrees of temperature changes, determine the *force* of the movement and the *extent* or *distance* of the movement.

See simple illustration above. The spiral type, produces a *turning* movement. When temperature drops, the Bimetal turns thermometer arrow in one direction. The temperature rises, the arrow is turned in the opposite direction.

The same principle (the spiral shape) is often used when the operating device of a product requires an electric switch to be turned on and turned off, or a valve to be opened or closed.

Made by an EXCLUSIVE Manufacturing Process . .

TOO much importance cannot be given to the manner in which the Bimetal you use in your product is made.

There are several ways in which to join two pieces of metal into one piece of Bimetal. Of these methods, only one is dependable, and that is—WELDING! Chace Thermostatic Bimetal is *welded* by an exclusive and specially developed process.

Another advantage of Chace Thermostatic Bimetal is—UNIFORMITY! One piece, or a million pieces, it is always the same. Each piece of a given specification, deflects and reacts exactly alike! This is a tremendous advantage to the product manufacturer who produces hundreds of thousands of his units each year, each unit containing a Bimetal element.

Each lot of raw material received at the Chace plant from the rolling mills is especially made to Chace specifications. Upon arrival from mill, each lot of metal is subjected to a rigid test, and only raw materials which completely meet the specifications are accepted.

The same principle of careful inspection and adherence to strict specifications is followed constantly while Chace Thermostatic Bimetal is under process of manufacture.

One piece—or a million pieces—you can completely depend upon Chace Thermostatic Bimetal.

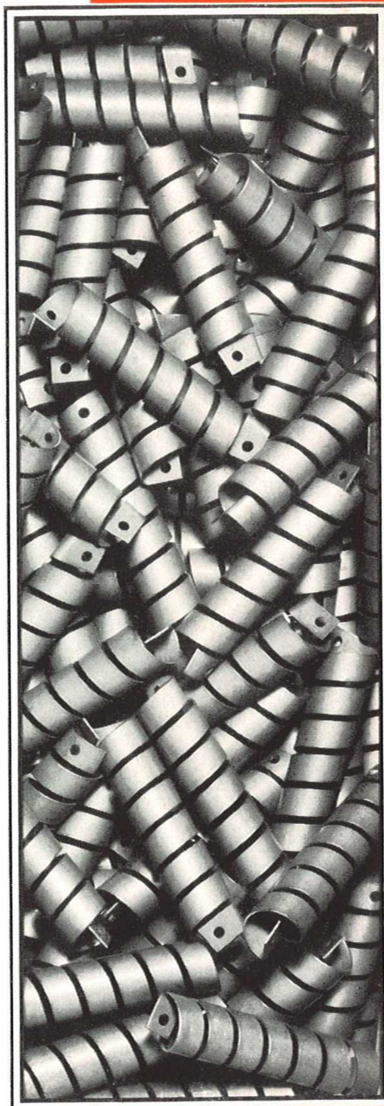
Absolute RELIABILITY and UNIFORMITY . .

•

Every Piece Deflects and Reacts Alike!

•

CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"



BIMETAL Correctly Applied

Brings Automatic Control to Any Product Where Temperature is a Factor in its Use . .

A FEW OF THE MANY DEVICES NOW OPERATED AUTOMATICALLY WITH BIMETAL . .

- Automatic Chokes
- Air Valves
- Alarm Devices
- Air Dryers
- Aquarium Heaters
- Air Heaters
- Altitude Meters
- Blue Print Machines
- Bread Wrapping Machines
- Chicken Brooders
- Circuit Breakers
- Carburetor Temperature Reg.
- Cord Sets (Iron)
- Clocks
- Candy Mixers
- Dental Furnaces
- Dental Sterilizers
- Draft Controls
- Damper Controls
- Demand Indicators
- Electric Instruments
- Electric Motors
- Fans
- Fire Alarms
- Glue Pots
- Gas Safety Pilots
- Hat Stretchers
- Hot Beds
- Heating Pads
- Ironing Machines
- Irons, Electric
- Incubators
- Laboratory Ovens (Gas)
- Laboratory Ovens (Electric)
- Light Flashers
- Machine Tools
- Motor Protection
- Necktie Pressers
- Oil Burner Controls
- Oil Purifiers
- Ovens, Electric
- Ovens, Gas
- Percolators
- Photo Mounting Machines
- Portable Electric Tools
- Pop Corn Machines
- Relays, Overload
- Relays, Signal
- Room Thermostats
- Room Thermometers
- Refrigerators
- Recording Thermometers
- Ranges, Electric
- Ranges, Gas
- Stack Controls
- Scales
- Shock Absorbers
- Signal Devices
- Sign Flashers
- Starting Devices
- Steam Radiators
- Steam Traps
- Time Switches
- Time Relays
- Type Metal Pots
- Transformer Indicators
- Toasters, Electric
- Vulcanizers
- Water Circulation, Auto
- Water Heaters, Electric
- Water Heaters, Gas
- Waffle Irons

THE constantly growing list of Chace Thermostatic Bimetal users is impressive. The unvarying quality and reliability of Chace has won us an enviable position in the industry and we are now constantly acquiring new friends and customers.

Leaders in the Automotive, Electrical, Gas and Oil Burner Industries, besides nationally known manufacturers in many other lines, are now using Chace Thermostatic Bimetal in preference to all other types.

Large users of thermostatic Bimetal have come to know from long experience that Chace Thermostatic Bimetal can be completely depended upon to operate their devices accurately under varying operating conditions.

Whether your needs for Bimetal be large or small, it will pay you to trust the dependable automatic operation of your product to Chace Thermostatic Bimetal.

These Nationally Known Manufacturers Approve CHACE Thermostatic BIMETAL . . .

DOUBTLESS you have seen the Chace series of advertisements which have been running in many of the industrial trade journals. A few of these advertisements are shown here.

Many prominent manufacturers have approved the quality and reliability of Chace Thermostatic Bimetal in this series of advertisements. Many of these leading manufacturers use Chace Thermostatic Bimetal—exclusively!

Many of them have been using Chace for years!

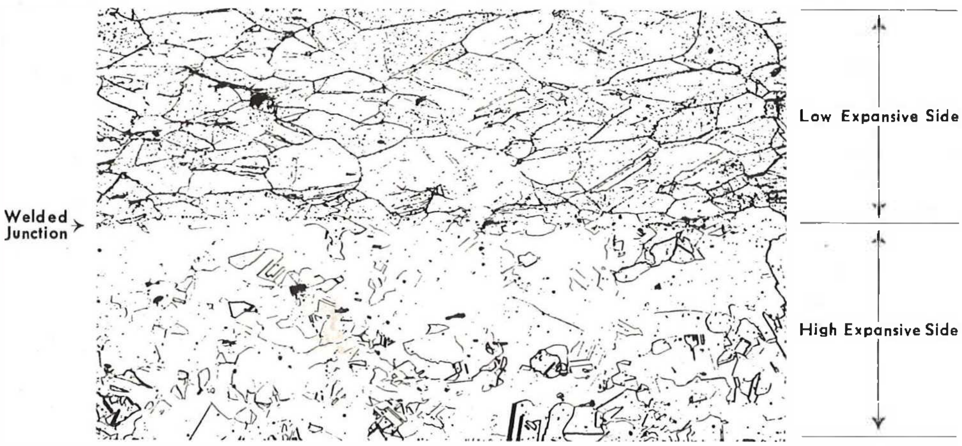
What greater and more significant approval could be given a product than such unanimous endorsement?

YOU, too, should be using Chace Thermostatic Bimetal.

THE Making of CHACE Thermostatic BIMETAL is an Art . . .

TO PRODUCE quantities of the various types of Bimetal, and to assure the utmost uniformity and dependability of each completed unit, the Laboratory must work side-by-side with the Manufacturing Plant. The process starts in the Laboratory—at the mills where the raw metals are rolled. When each shipment of the various kinds of raw stock arrives at the Chace plant, samples of each lot are taken into the Chace Laboratory for check-up and complete analysis. This raw stock, after being completely processed into Chace Thermostatic Bimetal, is again sampled for final tests in the Chace Laboratory. In addition to this constant flow of work through the Laboratory, the staff conducts multitudes of tests and experimental labors to further the development and application of Bimetal and also to assist manufacturers now turning

(Continued on Page 13)



PHOTOMICROGRAPH OF CROSS SECTION OF CHACE THERMOSTATIC BIMETAL

This is a photograph of a cross section of Chace Thermostatic Bimetal, taken with the photomicrographic camera in the Chace Laboratory. From the grain outline it is observed that there is no seam. To obtain this perfect bond no binder is used and even at red heat there is no possibility of the metals separating

How CHACE Thermostatic BIMETAL is Scientifically Tested in the CHACE Laboratory . .

toward Bimetal as the means of automatically operating their products.

Laboratory work being of such great importance, Chace has taken great care to install one of the finest laboratories of its kind. It is completely equipped with scientific apparatus as well as other laboratory equipment. Work done in this department accounts for much of the high quality and dependability of Chace Thermostatic Bimetal.

The Photomicrographic Camera

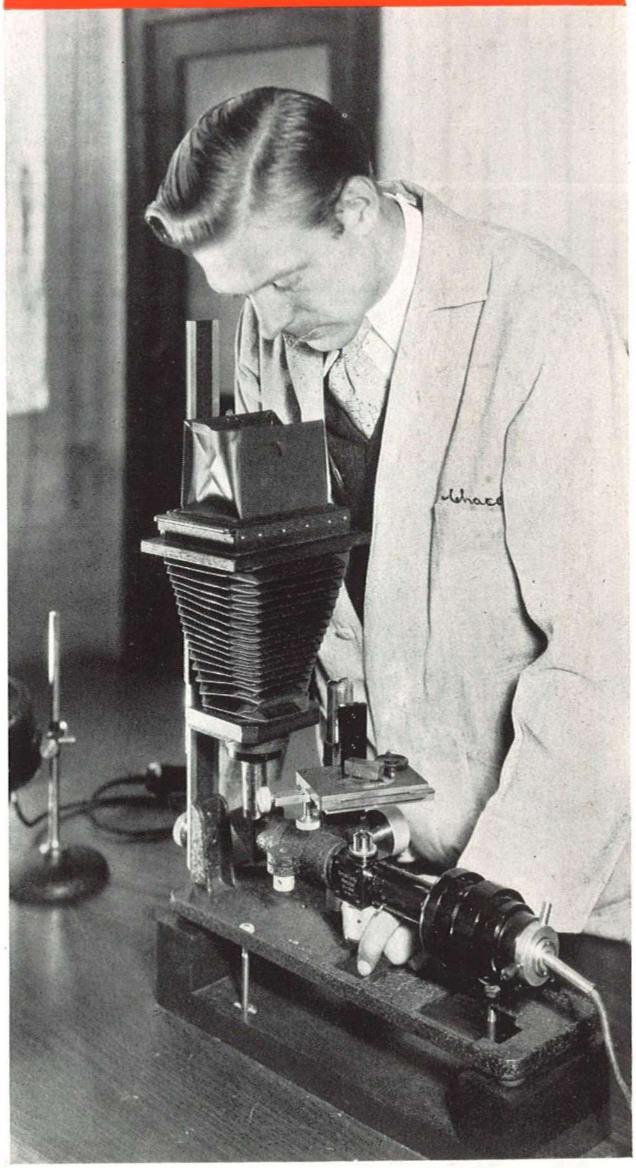
Known as the Leitz "Metallurscope," this apparatus is a combination of the microscope and camera.

The chief task of this scientific device is to determine the crystalline structure of metals as they pass through different steps during the manufacture of Chace Thermostatic Bimetal. It is also used to check the finished product.

While chemical analysis is important it is not conclusive. For example, a section of metal under chemical examination may measure 100% in accordance with the specification, while actually it may be unsuited for bimetal, due to incorrect heat treatment. Microscopical analysis therefore makes it possible to immediately ascertain the structure of the metal with reference to undesirable flaws or changes.

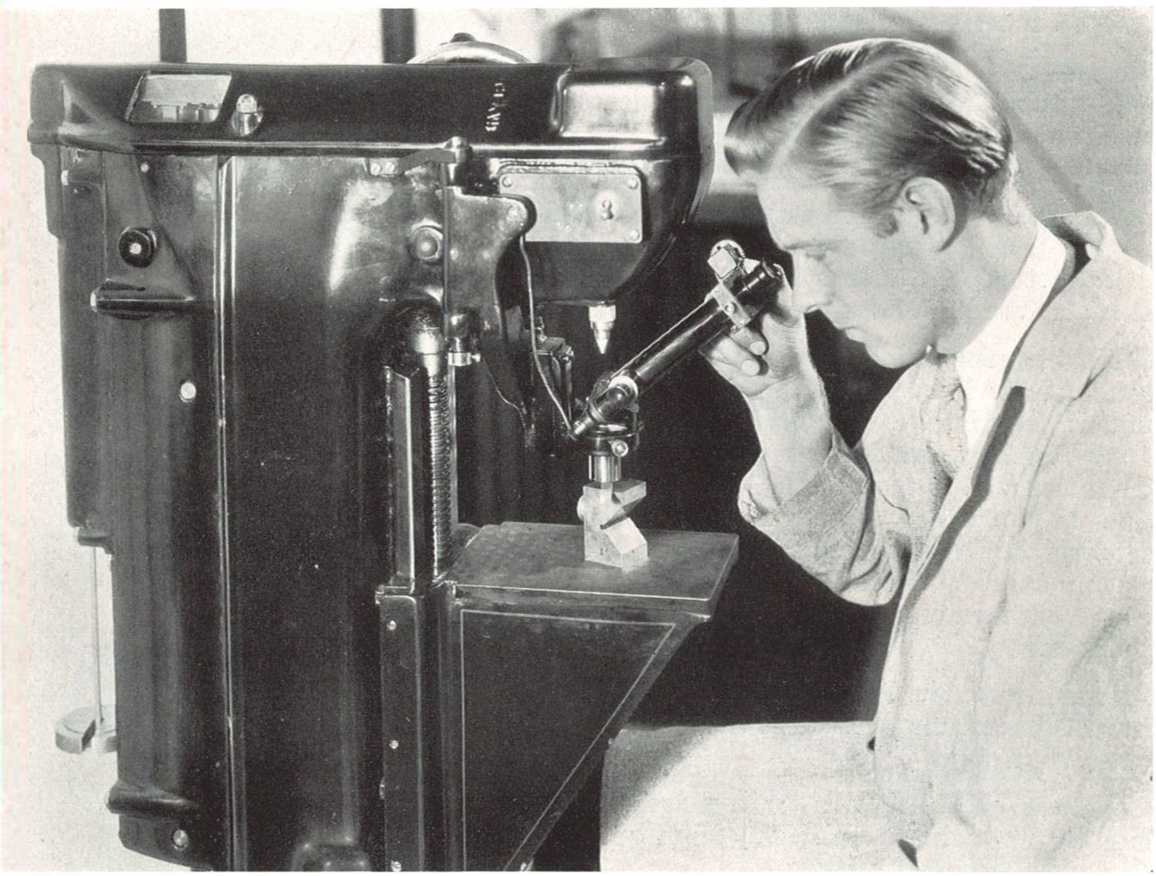
All metals used in Chace Thermostatic Bimetal must successfully pass analysis by the Leitz "Metallurscope."

Constant check-up with microscopic camera aids in producing a uniformly high quality of Chace Thermostatic Bimetal.



TESTING CHACE Thermostatic BIMETAL for Hardness . .

THE Vickers Pyramid Hardness Testing Machine is used in the Chace Laboratory to reliably and accurately test the hardness of metals used in Chace Thermostatic Bimetal. This machine performs tests on metals of all kinds, from very thin sheets to pieces of quite some thickness. The principle is simple: An indenter of definite shape is pressed into the metal, the resulting impression is accurately measured and the hardness is indicated. This indenter is a diamond, accurately cut and polished to the form of a square-based pyramid. The impressions are therefore square. The load is varied from 5 to 50 kilograms, according to requirements, and is automatically applied and removed in such manner that errors in loading are entirely eliminated. All Chace Thermostatic Bimetals must successfully pass this test.

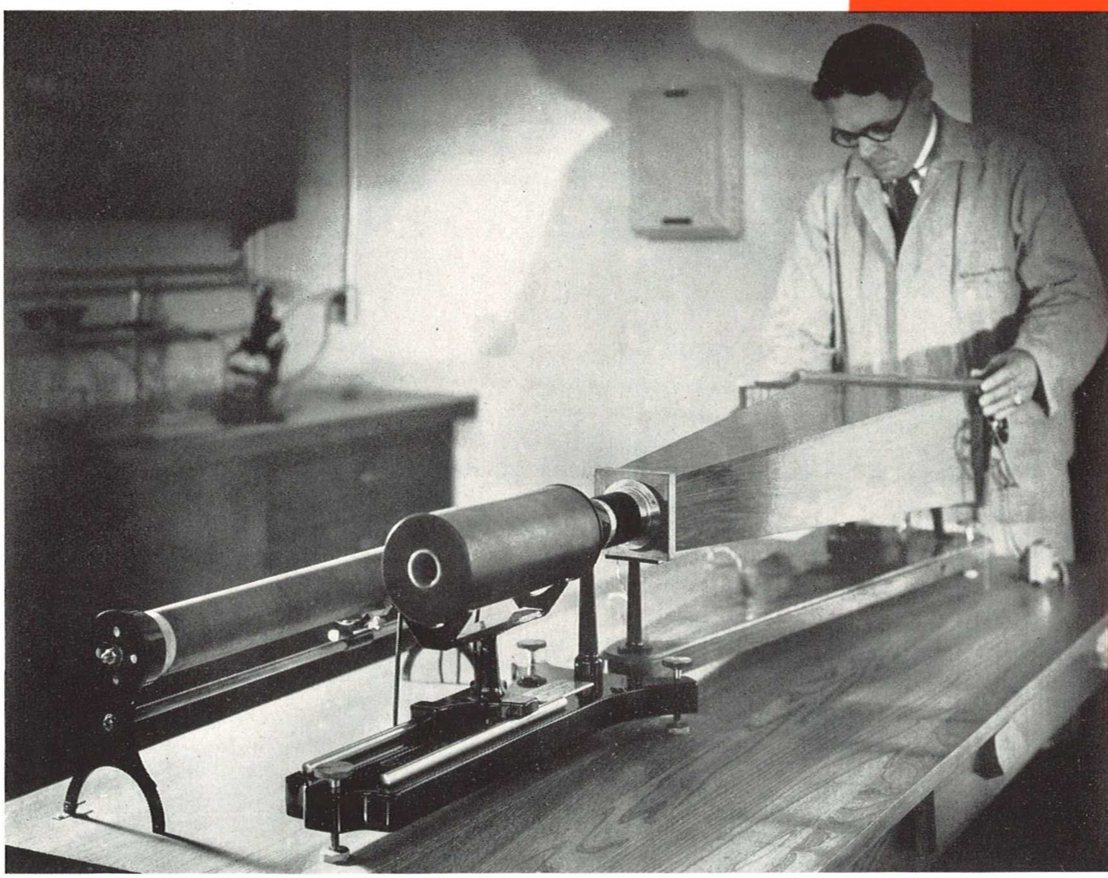


Testing CHACE Thermostatic BIMETAL for Expansion . . .

THE Chevenard Photographic Dilatometer photographically registers the expansion of metal while undergoing heat.

In the Dilatometer, the metal to be tested (in the form of a small rod) is placed in a quartz tube and then subjected to heat. The dilation is now transmitted into the photographic chamber by a ray of light which records the movement on a photographic plate.

This record is then checked with a comparative curve of a standard rod of definite known characteristic, thereby giving a definite measurement of expansion of the raw material.



RESEARCH and Experimentation in the CHACE Laboratory . . .

IN addition to the several scientific testing machines for maintaining the high standard of accuracy of Chace Thermostatic Bimetal, the Chace Laboratory also has a full complement of devices required for Metallurgical Research and Analysis.

Many experiments having to do with new applications of Bimetal have been successfully accomplished in the Laboratory Division.

As each year brings more and more manufacturers seeking automatic operation of their products, the Chace Laboratory carries a heavier load of this work.

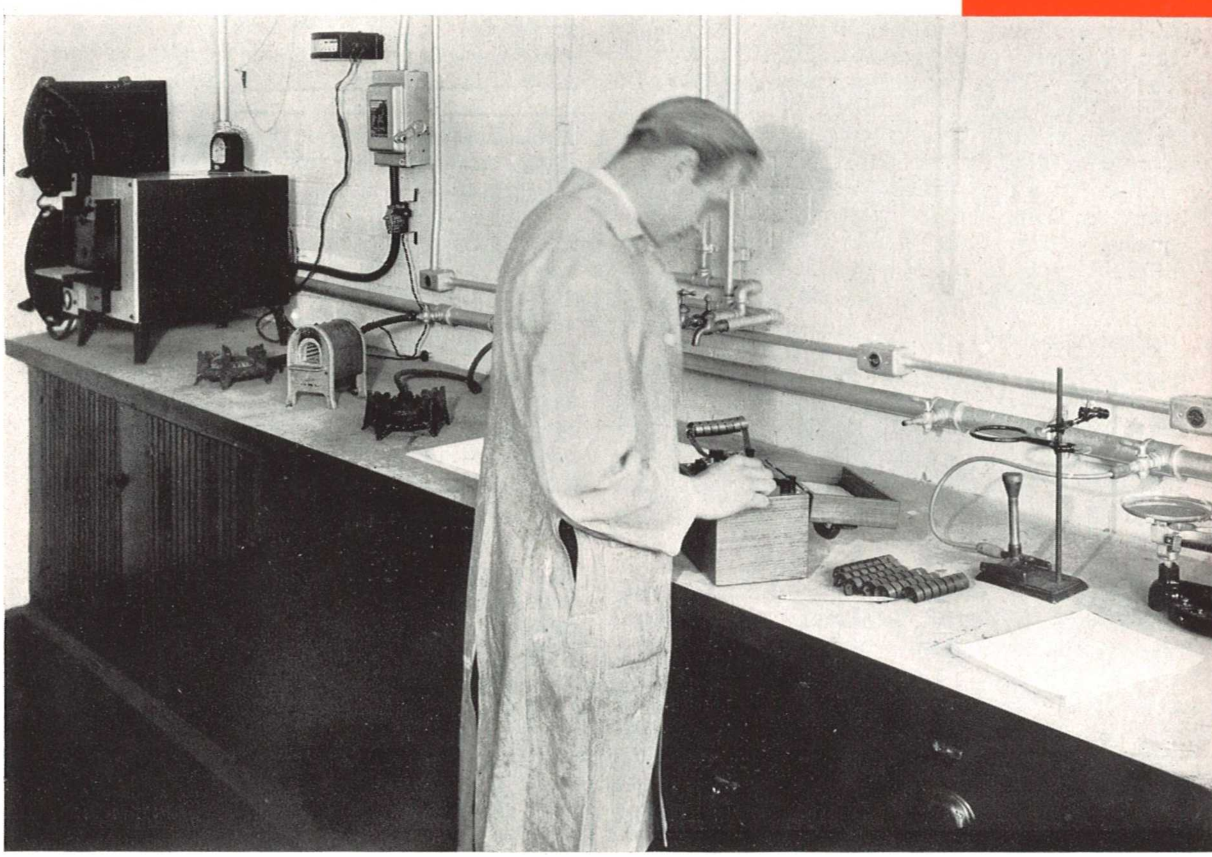
Each new product to be operated automatically brings its own individual set of problems which must be studied and solved by the Laboratory staff, before manufacturing begins.

CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"

Specialists in Solving Problems Concerning Automatic Operation . .

ONE manufacturer has a product which must start operating when temperature reaches a certain LOW point; another brings a product which must begin to function when temperature reaches a HIGH point; some products require a "twisting" movement to start; others a "pulling" or "pushing" movement.

All these are put before Chace specialists. They must study the product or operating mechanism thoroughly, after which recommendations are made covering a Chace Thermostatic Bimetal unit that will perform its given task accurately, reliably and indefinitely.



INSTRUCTIONS for Determining the Type and Dimensions of CHACE Thermostatic BIMETAL . .

APPLICATION:

The simple way in which thermostatic bimetal acts makes it applicable for an unlimited number of devices that function as temperature indicating or controlling means. It readily lends itself for use as a flat strip, "hair pin" or "U" shape, disc or coils. The coil is especially adapted to the dial type of device. The "U" shape makes it possible to secure maximum movement in a limited amount of space.

CHARACTERISTICS:

In order to provide as great sensitivity as possible for a definite working range, several types of thermostatic bimetal are available. High or low temperature applications can best be met by selecting a type that gives the greatest sensitivity within the desired working temperature. Thermostatic bimetal, to have proper resiliency and strength, receives a certain amount of cold rolling in the manufacture. Internal stresses are set up which should be removed by heat treatment, before putting the parts into service. The data sheets prepared on the different types of metal describe the heat treatment process.

TEMPERATURE:

The working temperature and the maximum temperature that the bimetal element will be subjected to, determines whether high or low temperature types will be selected.

In general, the most sensitive type within the required range is selected as it reduces the size of the piece to a minimum. When a wide range of adjustment is desired in a small space, a less sensitive metal may work out the best. By referring to the deflection curves a comparison is readily seen for the different types.

DEFLECTION:

The deflection of a bimetal strip with one end fixed, measuring the movement of the free end at right angles from the cold position, varies with the square of the length, inversely with the thickness and for practical purposes directly proportional to the temperature change up to a predetermined temperature limit. For example, a piece eight inches long would have four times the deflection of a four inch length, while a piece two inches long would have just one fourth the deflection of a four inch length. Reducing the thickness one half would double the deflection and doubling the thickness would reduce the deflection by one half.

The angular deflection of a spiral or helix varies directly with the length of the strip, inversely as the thickness of the material, and directly proportional to the temperature change. The number of turns or the diameter of either element does not materially affect the deflection. As far as angular movement is concerned with the same size of strip, there is no appreciable advantage whether the coil is in the form of a spiral or helix. Coils may be formed to either wind-up or unwind with increase of temperature.

It is desirable that sufficient room be allowed between turns so that under extreme temperature conditions there is opportunity for air circulation as well as mechanical clearance to avoid any friction or binding of the turns. For this reason it is recommended that coils be made to unwind with increase of temperature. The turns may be wound either right hand or left hand for helices to give the desired rotation. A helix unwinding with increase of temperature has also a slight elongation. It is necessary that this be taken into consideration so that there is no friction introduced by the end thrust of the coil.

TORQUE:

The force exerted by the free end of a straight strip, assuming it to be under restraint due to a change in temperature, varies directly with the width of the strip, the cube of the thickness and inversely with the cube of the length. This applies at normal temperature and allowance must be made for elevated temperatures, as under such conditions the strength of the material is greatly reduced. In the formulas given for calculating the torque of either spirals or helices, expressed in pound-inches, the radius may be selected as the distance from the center to the point at which the load is applied.

The formula estimating the maximum stress in a helix or spiral is the same as for the straight strip. The turning moment is the same for both arrangements so that any limitations mentioned regarding the strength of a straight strip would also apply to spirals and helices. At elevated temperatures the strength is reduced. The reference table shows maximum working stress values for high temperature bimetal with respect to temperature. A reasonable factor of safety has been selected based on years of performance in service.

CONSTRUCTION:

For satisfactory bimetal in applications where red heat is encountered the weld of the component elements must be such as to make a perfect bond. In the fabrication of Chace High Temperature Thermostatic Bimetal no binder or intermediary material is used. Under red heat there is no possibility of the metals separating. It should be noted from the grain structure in the Photomicrograph that there is no seam.

HEAT TREATMENT:

In order to give permanence to the element after it is cut and formed, a heat treatment is necessary. This can be made in an ordinary electric or gas heated oven. It is recommended that the heat treatment consist of one three hour period. After the heating, the pieces should be removed and allowed to cool in air to room temperature. Owing to the movement of the metal when subjected to heat, care should be taken that the parts are free in the oven so as to permit natural deflection without the metal being restrained. It will be noted that in the data given with the formulas that the sensitivity of the metal is affected to a certain extent by the temperature of the heat treatment. For the low temperature metal, type No. 1800, the heat treatment is made at 300° F. For the other types, which are high temperature metals, a minimum value of 700° F. should be used for the heat treatment and it is advisable if the operating temperature while in service is higher than this, to select a heat treatment temperature that is, at least, 100° in excess of the maximum value that the material will be subjected to after it is installed.

Heat treatments at 700° F., 850° F., or 1000° F. have been adopted as standard, as they cover the majority of applications. Corresponding deflection constants for these values are given on the curve sheets for the various types of bimetal.

SIZE: (1) Sheets—

Chace thermostatic bimetal comes in standard sheets 3″ wide for thickness up to .030″, and 6″ wide from .030″ up to .100″ in random lengths from 6 to 8 feet. Standard thickness runs from .010″ to .100″. The material is shipped flat with the low expansive side marked for identification.

SIZE: (2) Strips—

Sheets can be slit into strips of your required width. For very thin material the length should not exceed 2 or 3 feet in order to prevent bending when handling. It will be seen from the preceding paragraph that the Standard width of Bimetal sheets is 3″ and 6″, it is therefore a matter of economy to order strips that will slit in equal parts (without waste) from these sheets of standard width.

SIZE: (3) Finished Pieces—

Blanked or formed pieces can be furnished complete, heat treated ready for assembly in accordance with sample or customer's drawing. Drawing should specify the direction of movement with increase of temperature so that the pieces may be correctly formed.

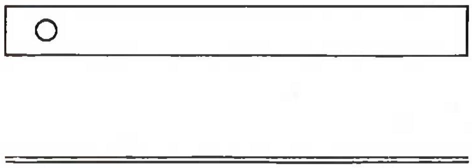
SELECTION OF ELEMENTS:

In general, the shape of a bimetal element is selected depending upon whether a straight line motion or a rotary motion is required. For simple thermostats as in ordinary electric irons a straight strip is sufficient. For room temperature controls requiring sensitivity within one degree, the element may have several turns at the stationary end in order to have sufficient length within a reasonable mounting space.

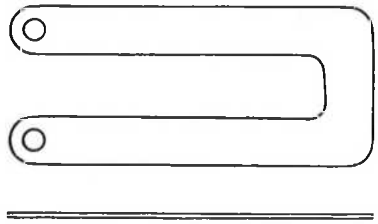
For indicating thermometers or oven controls requiring a graduated dial either a helix or spiral coil would be used. Formulas are given for the different bimetal types to aid as a preliminary step in the selection of a proper size unit. Deflection curves are also given for each type for a straight strip 4″ in length from thicknesses of .010″ to .100″. Samples should be made up for test before any large quantity is considered, as some factors, such as time-lag, etc., may enter in which can only be determined by actual test.

REPRESENTATIVE Bimetal Elements . .

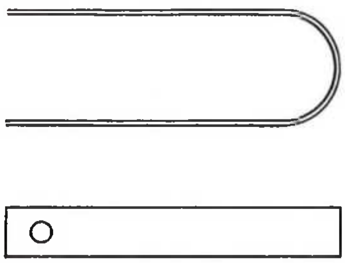
In general, the dimensions of each shape are determined by the requirements of the individual application. Detailed information covering temperature, movement and type of application, will enable our Engineering Department to make recommendation for at least a preliminary sample.



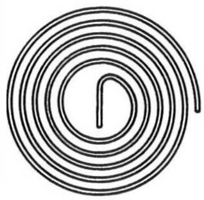
(1) STRIP



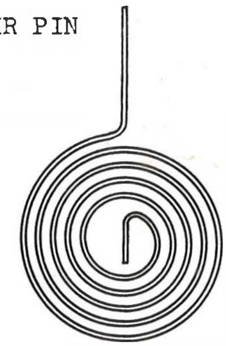
(2) HAIR PIN



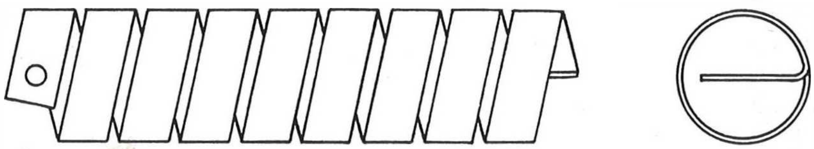
(3) U-SHAPE



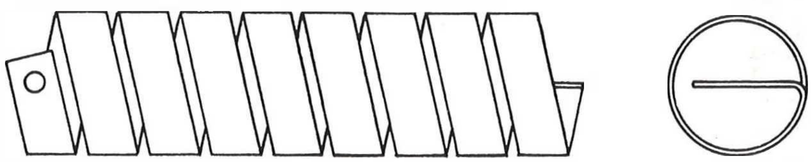
(4) SPIRAL



(5) SPIRAL



(6) HELIX (LEFT HAND WOUND)



(7) HELIX (RIGHT HAND WOUND)

TYPES of Bimetal . . .

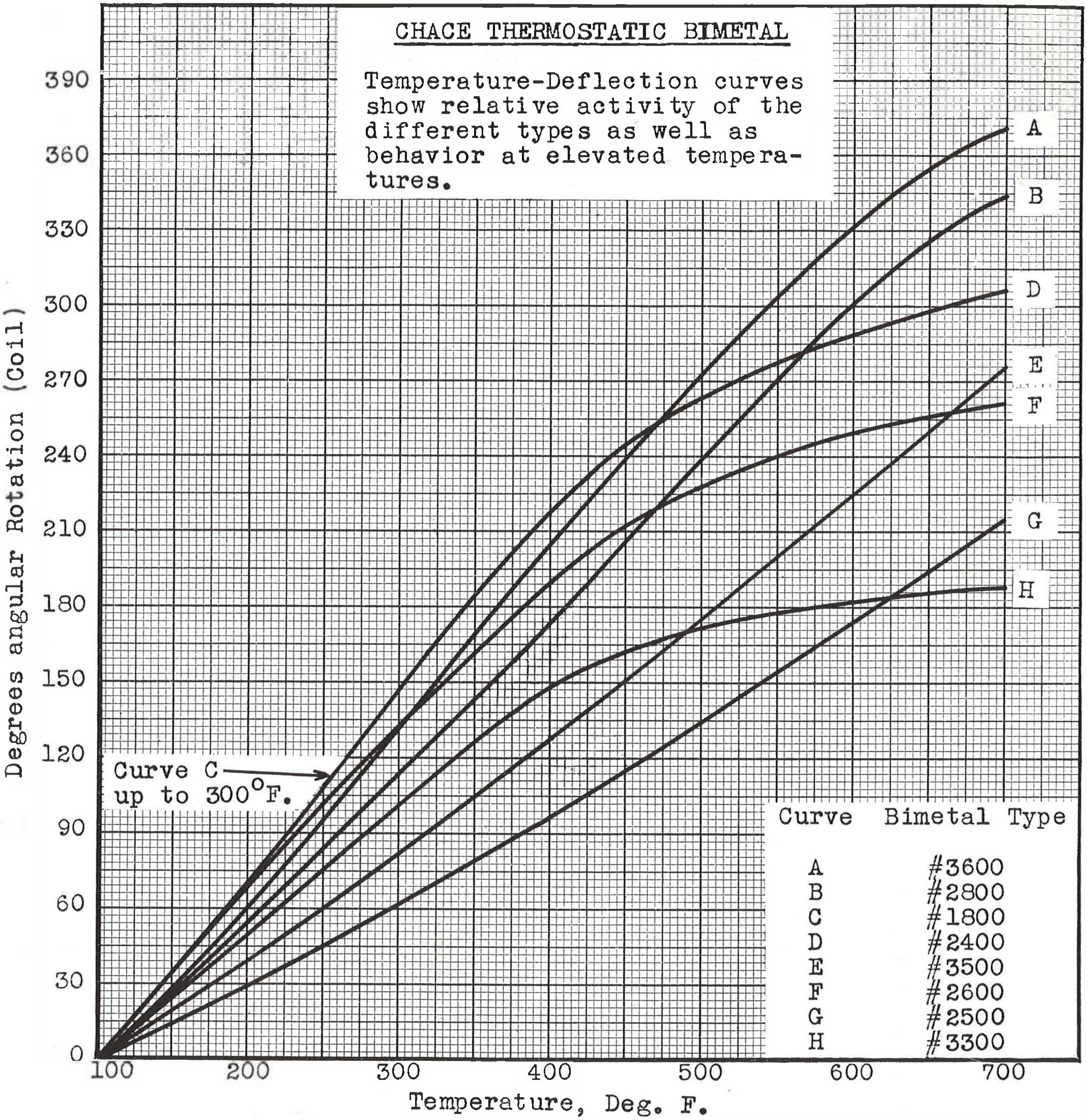
CHACE Thermostatic Bimetal is Available in the Following Types . . .

Bimetal Types	Marking on Low Expansive Side		Active Range of Deflection	Maximum Working Temperatures
	Color	Letter		
Chace No. 1800	(Steel)	None	−50° to +300° F.	300° F.
Chace No. 2400	White	S	−50° to +500° F.	1200° F.
Chace No. 2500	Black	C	−50° to +900° F.	1200° F.
Chace No. 2600	Red	X	−50° to +450° F.	1200° F.
Chace No. 2800	Green	Y	−50° to +650° F.	1200° F.
Chace No. 3300	Yellow	V	−50° to +400° F.	1200° F.
Chace No. 3500	Blue	L	−50° to +800° F.	1200° F.
Chace No. 3600	Orange	B	−50° to +700° F.	1200° F.

Electrical Resistivity . . .

In some applications current is carried by the bimetal strip, and a temperature rise results from the heating effect of the current. Owing to varied radiation factors in control devices, no definite figures can be given as to the temperature rise on a given element. To assist in making comparison of the different types, the following resistance values are given.

Bimetal Types	Resistance at 80° F. Ohms per Cir. Mil-Ft.	Bimetal Types	Resistance at 80° F. Ohms per Cir. Mil-Ft
Chace No. 1800	90	Chace No. 2800	450
Chace No. 2400	470	Chace No. 3300	110
Chace No. 2500	350	Chace No. 3500	410
Chace No. 2600	510	Chace No. 3600	410



CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"

FORMULAS for Engineering Reference . .

Deflection and Pull of Straight Strips, Spirals and Helices of CHACE Thermostatic Bimetal . .

D = Deflection at end of strip in inches.

A = Movement in degrees (Angular)

T_1-T = Temperature rise degrees F.

l = Length of strip in inches.

t = Thickness of strip in mills.

r = Radius (in inches) of point at which load (P) is applied.

b = Width of strip in inches.

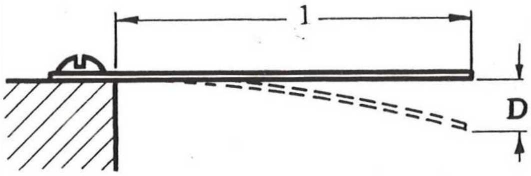
P = Pull in pounds at 80° F.

f = Pounds per square inch. (maximum)

k = Constant varying with metal type.

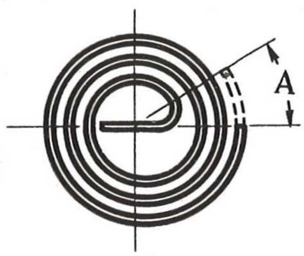
DEFLECTION (Straight Strips)

$$D = \frac{k\,(T_1 - T)\,l^2}{t}$$

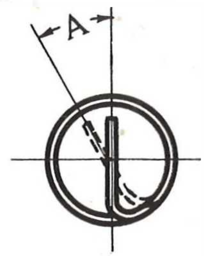


ANGULAR DEFLECTION (Coils)

$$A = \frac{k\,(T_1 - T)\,l}{t}$$



SPIRAL



HELIX

TORQUE (Strips)

$$P = \frac{k\,D\,b\,t^3}{l^3}$$

TORQUE (Coils)

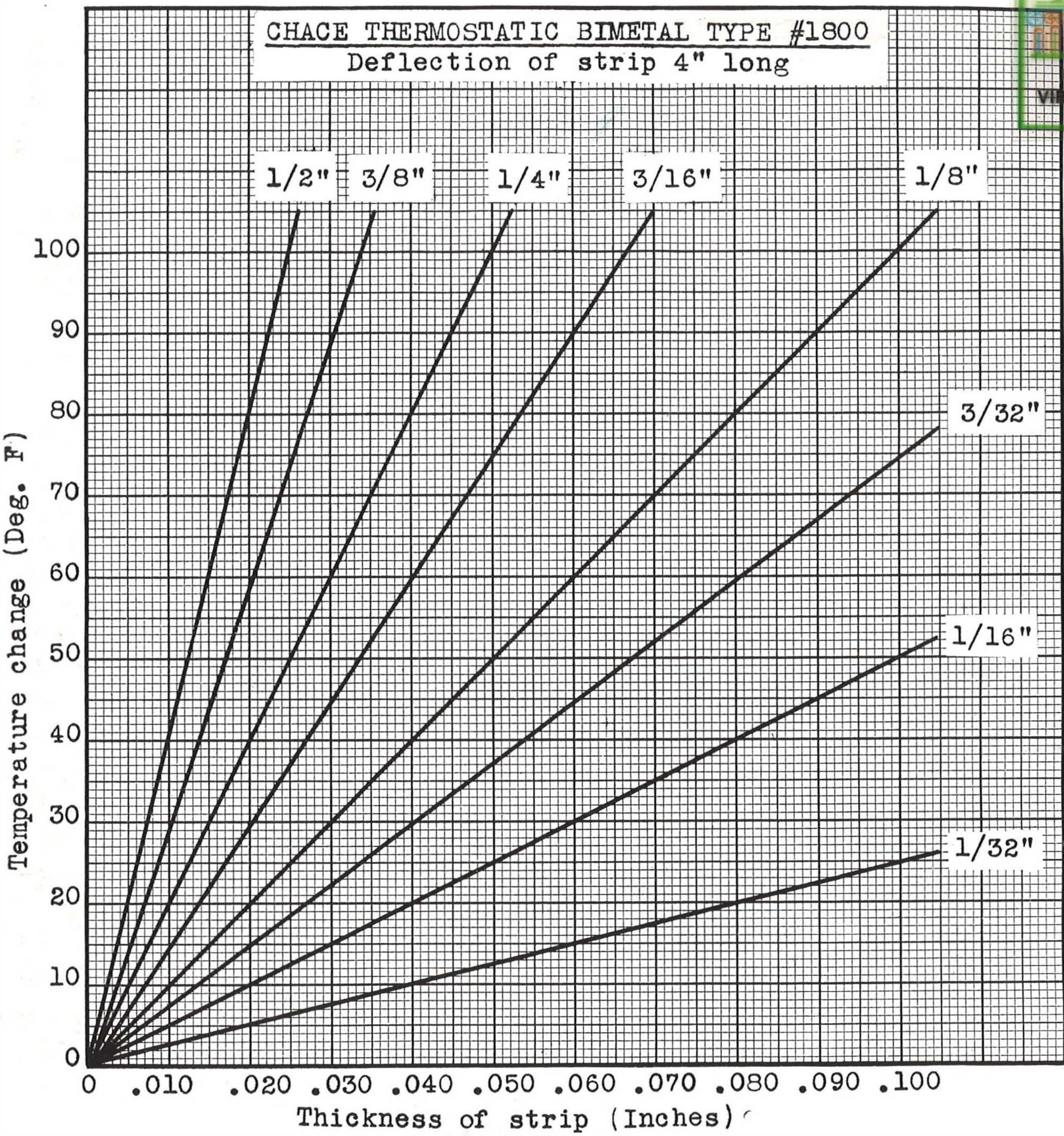
$$P = \frac{k\,A\,b\,t^3}{l\,r}$$

STRESS IN MATERIAL

$$f = \frac{6{,}000{,}000\ Pr}{bt^2}$$

Working stress (f) should not exceed the following values for temperatures up to 1200° F.

Temperature	Pounds per Sq. In.
100° F.	25,000
200° F.	23,000
400° F.	20,000
600° F.	15,000
800° F.	12,000
1000° F	7,000
1200° F.	3,000

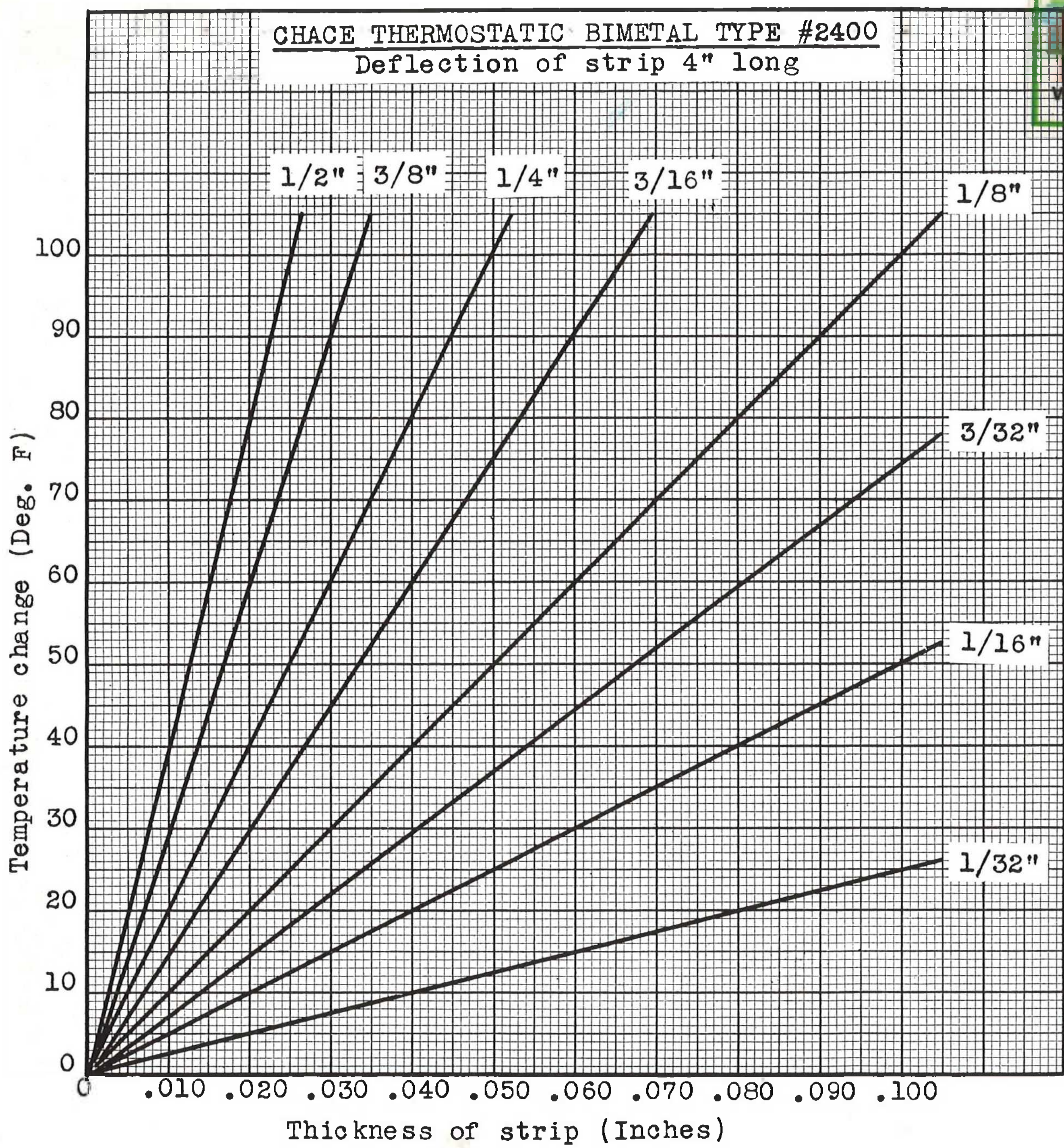


1. A bimetal with high sensitivity for low temperature applications.
2. Active deflection up to 300° F.
3. Maximum permissible working temperature 300° F.
4. Deflection constant (k) at 300° F. heat treatment temperature.
   For formula on strips k = .0077
   For formula on coils k = .90
5. Torque constant (k) at 80° F:
   For formula on strips k = .0050
   For formula on coils k = .000024
6. Resistance = 90 ohms per Cir. Mil-Ft.

CHACE THERMOSTATIC BIMETAL

"It Bends with the Heat"

Type No. 1800



1. A bimetal with high sensitivity for high temperature applications.
2. Active deflection up to 500° F.
3. Maximum permissible working temperature 1200° F.
4. Deflection constant (k) as follows:

	Heat Treatment Temperature		
	700° F.	850° F.	1000° F.
For formula on strips	.0077	.0072	.0075
For formula on coils	.90	.84	.87

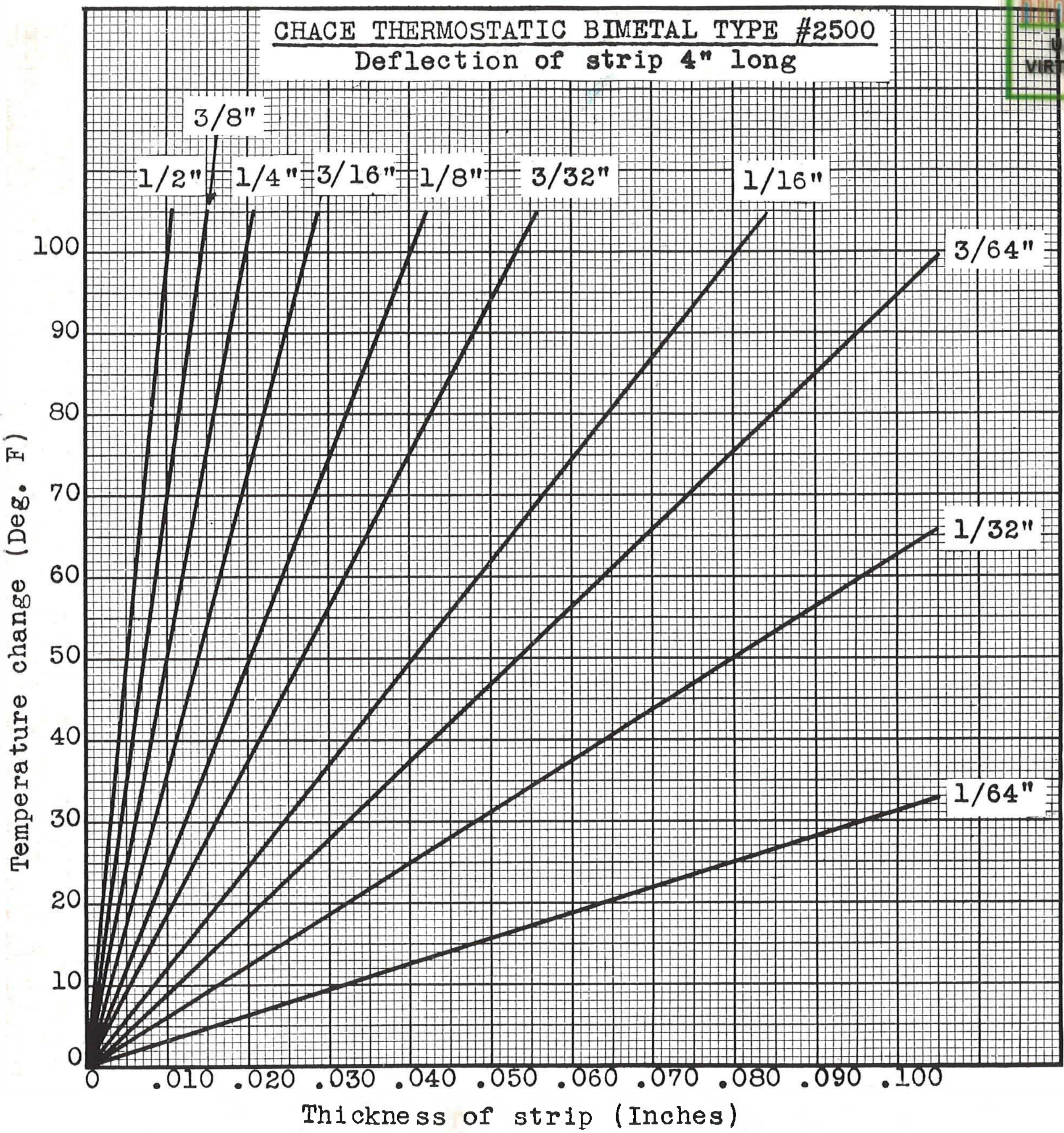
5. Torque constant (k) at 80° F.:

   For formula on strips k = .0065
   For formula on coils k = .000031

6. Resistance = 470 ohms per Cir. Mil-Ft.

CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"

Type No. 2400



1. A low sensitivity bimetal for high temperature applications.
2. Active deflection up to 900° F.
3. Maximum permissible working temperature 1200° F.
4. Deflection constant (k) as follows:

	Heat Treatment Temperature		
	700° F.	850° F.	1000° F.
For formula on strips	.0031	.0028	.0029
For formula on coils	.37	.35	.35

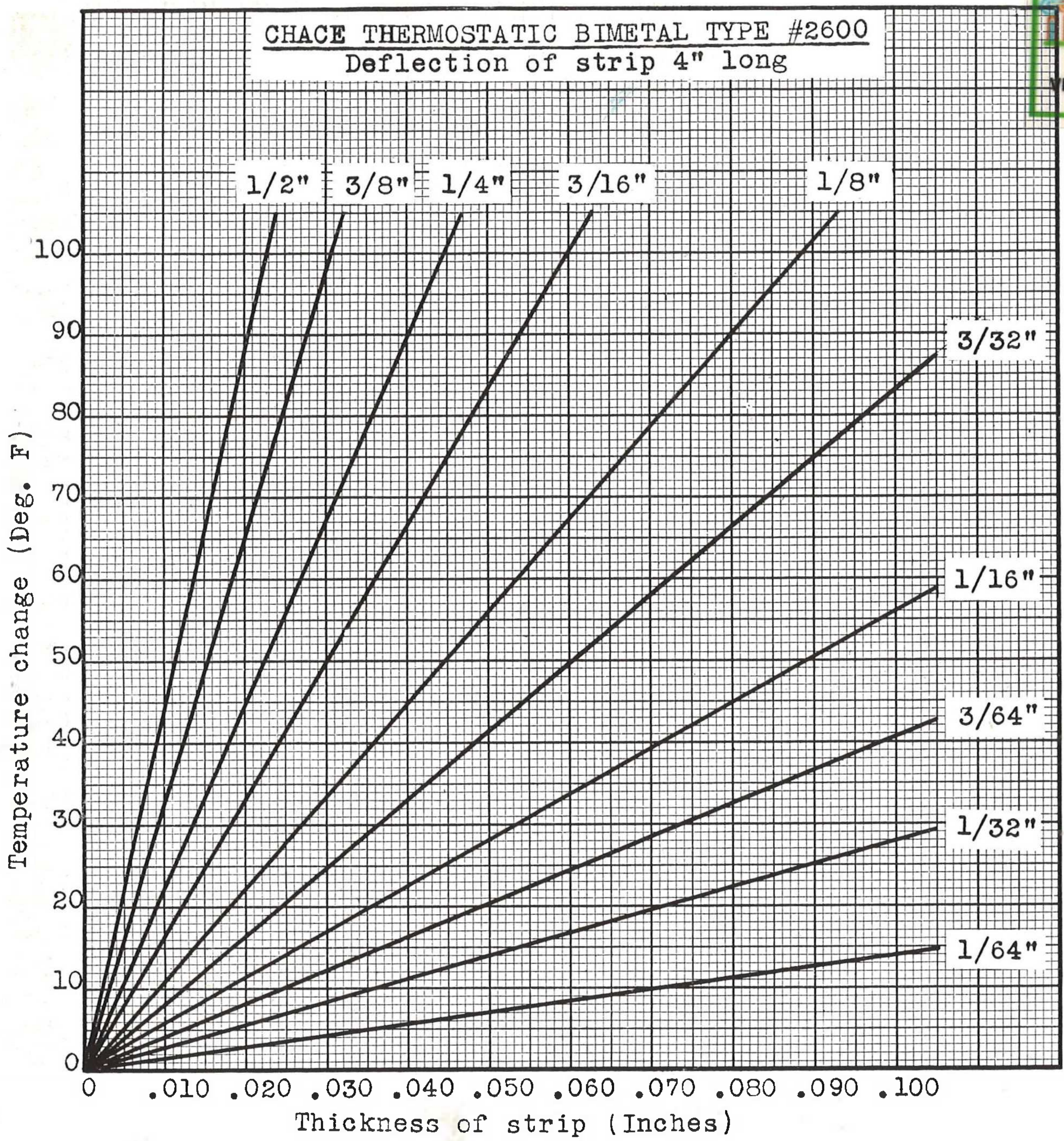
5. Torque constant (k) at 80° F.:

   For formula on strips k = .0065
   For formula on coils k = .000031

6. Resistance = 350 ohms per Cir. Mil-Ft.

CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"

Type No. 2500



1. A bimetal with high sensitivity.
2. Active deflection up to 450° F.
3. Maximum permissible working temperature 1200° F.
4. Deflection constant (k) as follows:

	Heat Treatment Temperature		
	700° F.	850° F.	1000° F.
For formula on strips	.0068	.0065	.0066
For formula on coils	.80	.76	.77

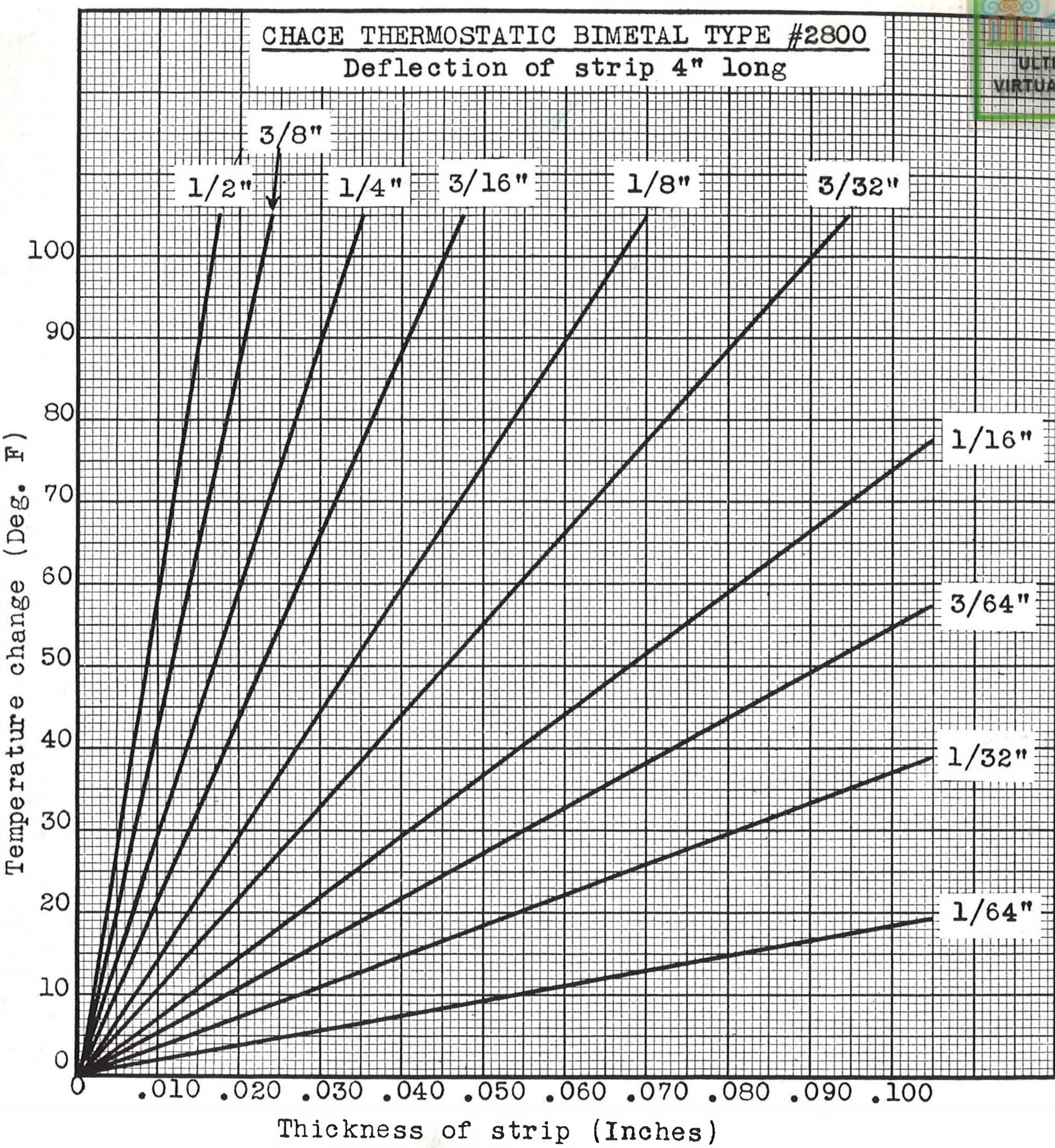
5. Torque constant (k) at 80° F.:

   For formula on strips k = .0065
   For formula on coils k = .000031

6. Resistance = 510 ohms per Cir. Mil-Ft.

CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"

Type No. 2600



CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"

Type No. 2800

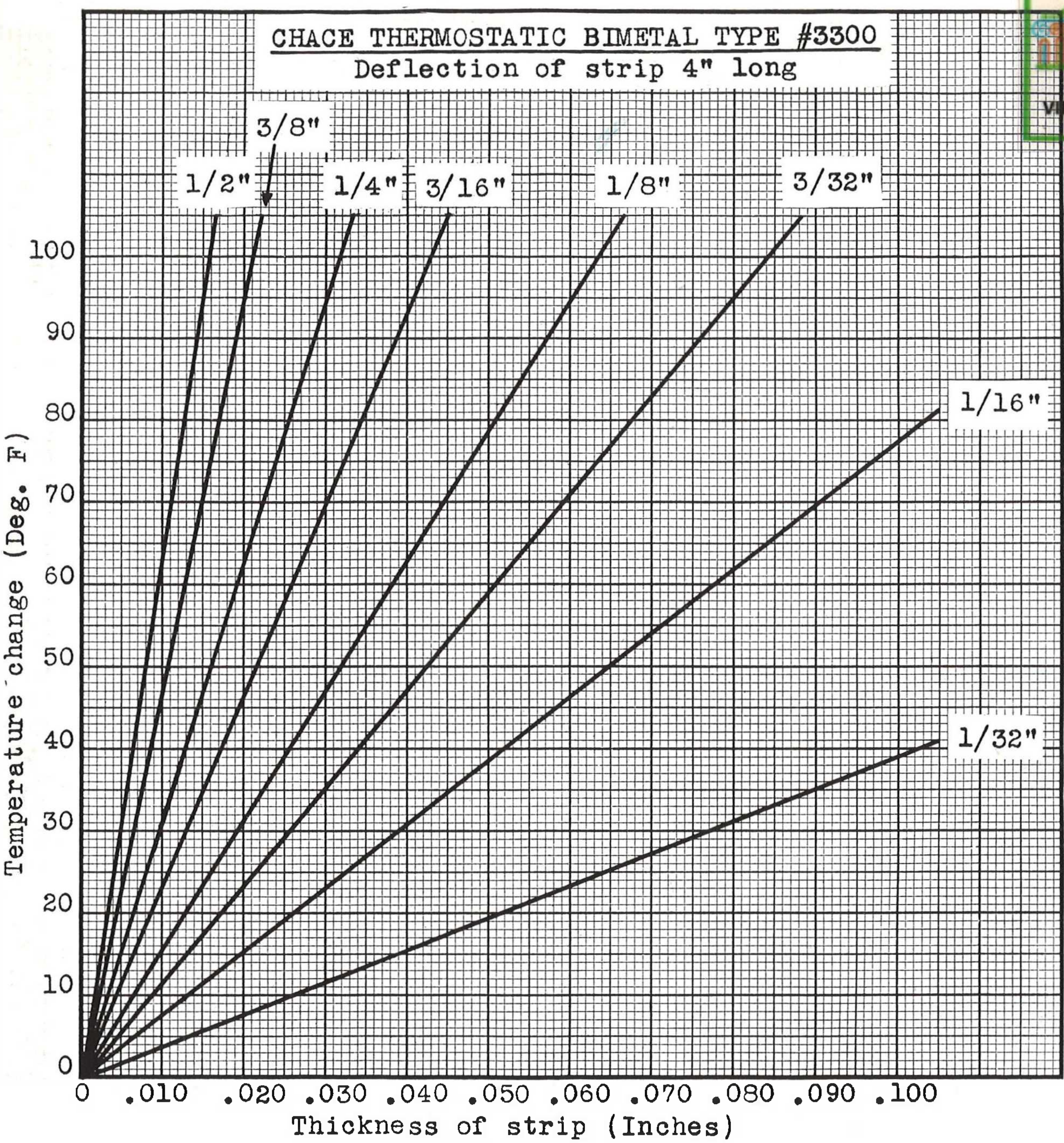
1. A sensitive bimetal for high temperature applications.
2. Active deflection up to 650° F.
3. Maximum permissible working temperature 1200° F.
4. Deflection constant (k) as follows:

	Heat Treatment Temperature		
	700° F.	850° F.	1000° F.
For formula on strips	.0050	.0047	.0047
For formula on coils	.62	.57	.57

5. Torque constant (k) at 80° F.:

For formula on strips k = .0065
For formula on coils k = .000031

6. Resistance = 450 ohms per Cir. Mil-Ft.



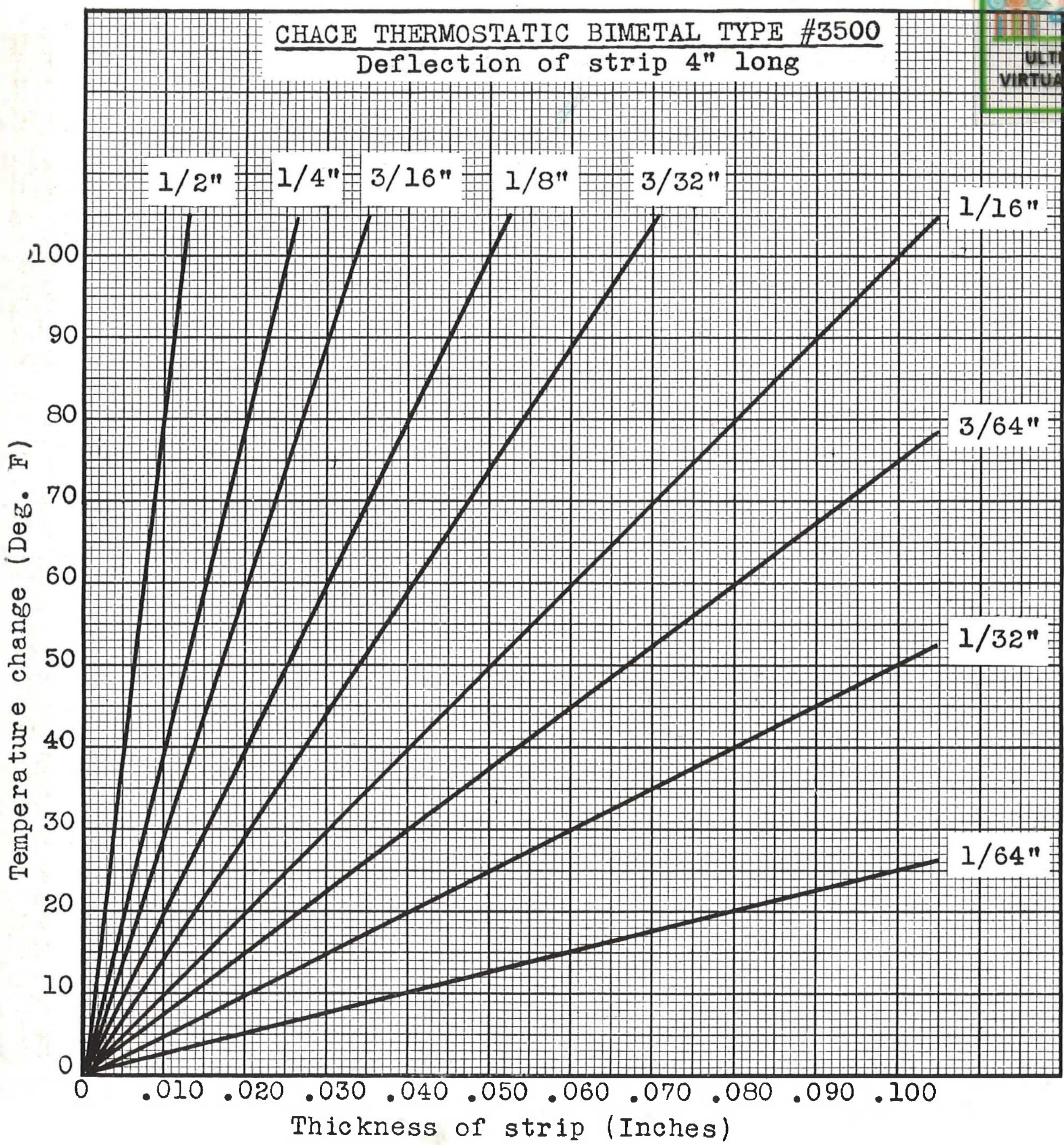
1. A low resistance bimetal for high temperature applications.
2. Active deflection up to 400° F.
3. Maximum permissible working temperature 1200° F.
4. Deflection constant (k) as follows:

	Heat Treatment Temperature		
	700° F.	850° F.	1000° F.
For formula on strips	.0048	.0045	.0045
For formula on coils	.59	.53	.53

5. Torque constant (k) at 80° F.:
   For formula on strips k = .0065
   For formula on coils k = .000031
6. Resistance = 110 ohms per Cir. Mil-Ft.

CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"

Type No. 3300



CHACE THERMOSTATIC BIMETAL

"It Bends with the Heat"

Type No. 3500

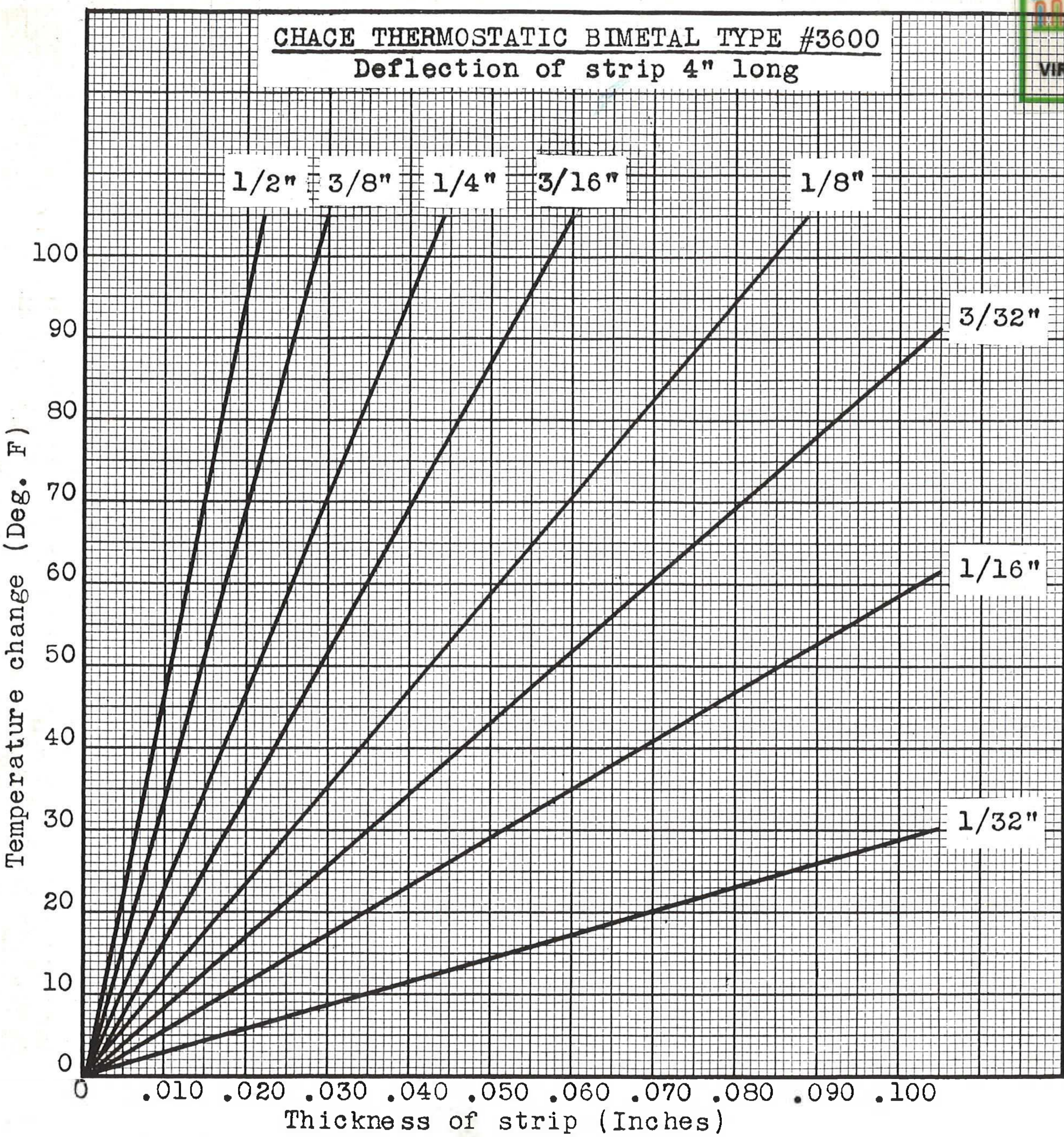
1. A sensitive bimetal for high temperature applications.
2. Active deflection up to 800° F.
3. Maximum permissible working temperature 1200° F.
4. Deflection constant (k) as follows:

	Heat Treatment Temperature		
	700° F.	850° F.	1000° F.
For formula on strips	.0040	.0038	.0037
For formula on coils	.48	.46	.44

5. Torque constant (k) at 80° F.:

   For formula on strips k = .0065
   For formula on coils k = .000031

6. Resistance = 410 ohms per Cir. Mil-Ft.



1. A highly sensitive bimetal for high temperature applications.
2. Active deflection up to 700° F.
3. Maximum permissible working temperature 1200° F.
4. Deflection constant (k) as follows:

	Heat Treatment Temperature		
	700° F.	850° F.	1000° F.
For formula on strips	.0065	.0061	.0062
For formula on coils	.78	.73	.74

5. Torque constant (k) at 80° F.:

   For formula on strips k = .0065
   For formula on coils k = .000031

6. Resistance = 410 ohms per Cir. Mil-Ft.

CHACE THERMOSTATIC BIMETAL

"It Bends with the Heat"

Type No. 3600

LET Us Help You Solve Your Automatic Control Problems . .

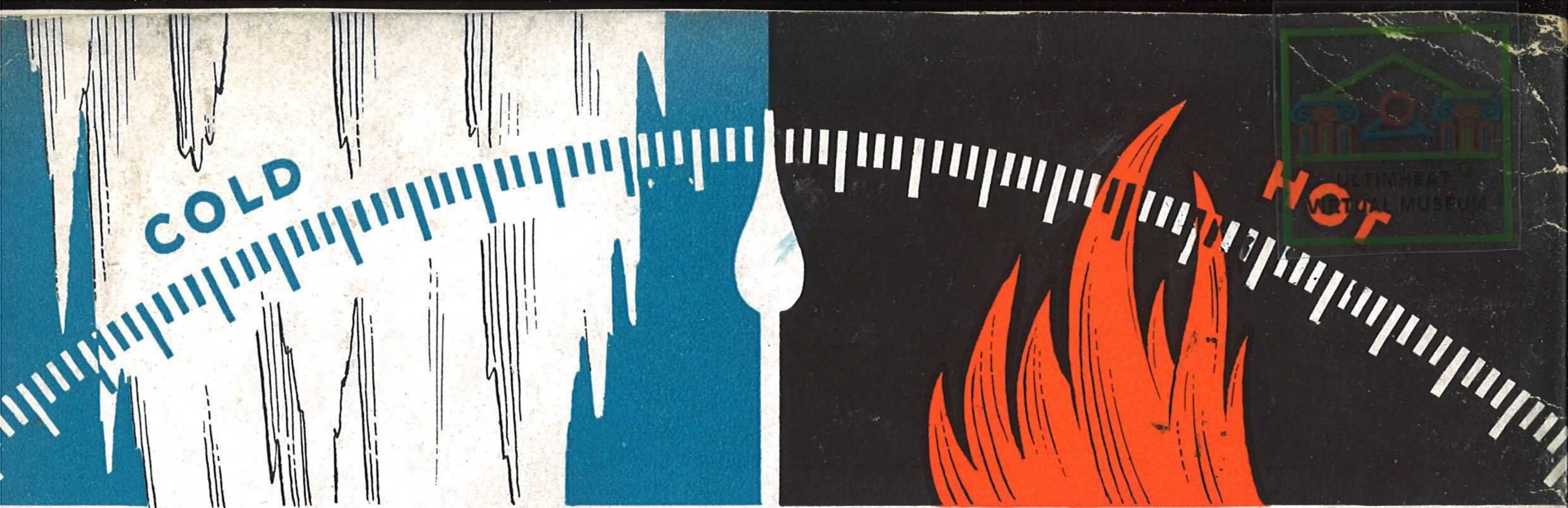
IT will be seen from the foregoing that the manufacturers of Chace Thermostatic Bimetal work in close coöperation with the many manufacturers of products using Chace Thermostatic Bimetal.

While we supply Bimetal in sheets and strips to those customers who maintain shop equipment for shaping and forming their Bimetal units, it is significant that more and more users are turning toward our complete Bimetal service, wherein we furnish units completely shaped and ready for installation.

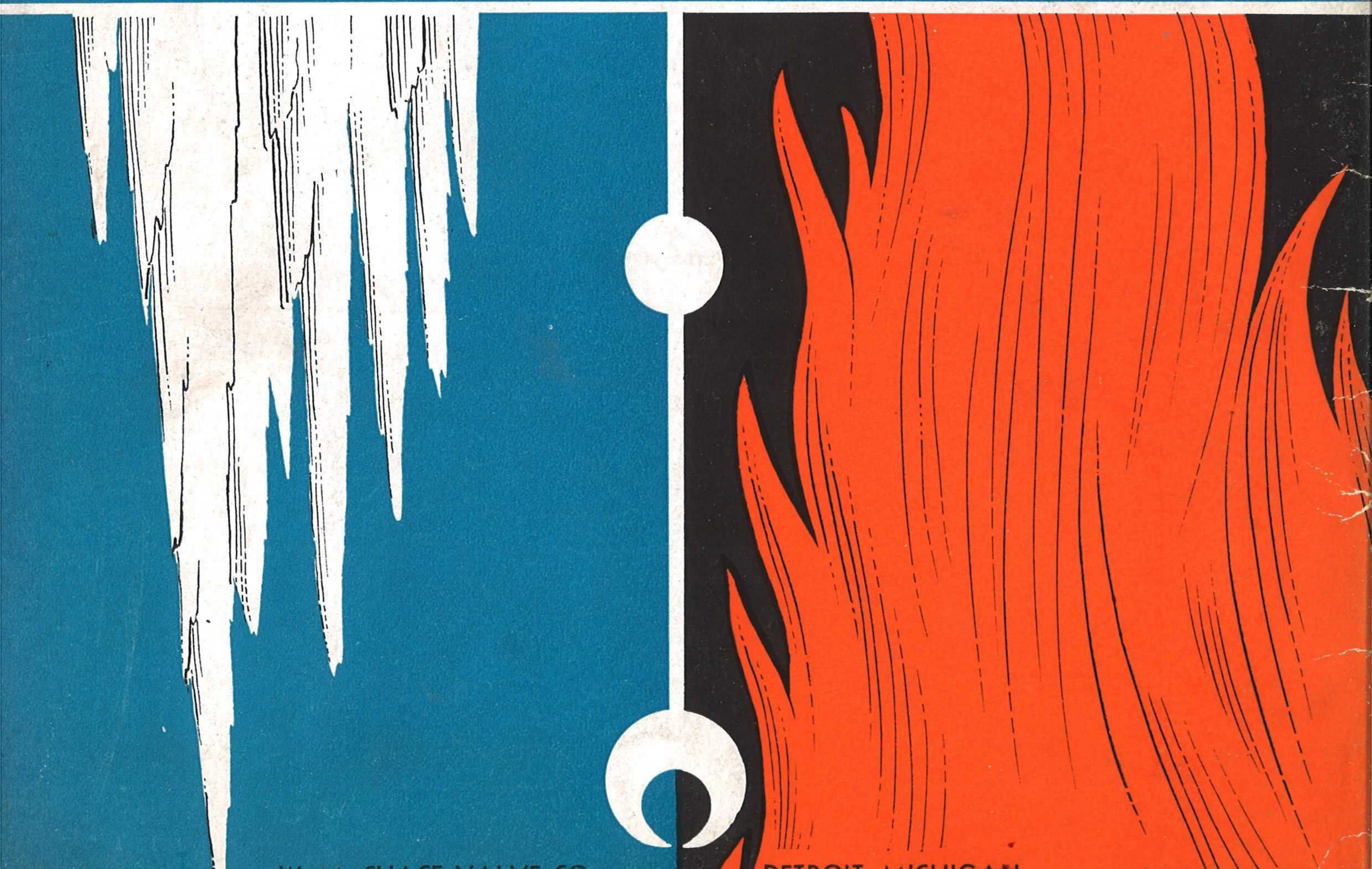
We welcome your problems in automatic control. Our staff of engineers consists of men long experienced in this work. Necessarily, much of our special design work is confidential. We keep that faith in the strictest sense of the word. Have no hesitancy in calling upon Chace to assist you.

A simple and confidential information form accompanies this book. Feel free to use it without obligation on your part. It costs you nothing to learn more about the quality and reliability of Chace Thermostatic Bimetal.

W. M. CHACE VALVE COMPANY
1602 Beard Avenue
DETROIT :: MICHIGAN



Thermostatic BIMETAL



W. M. CHACE VALVE CO. DETROIT, MICHIGAN