

Fig. 1 Spectral power distribution of black body at various temperatures

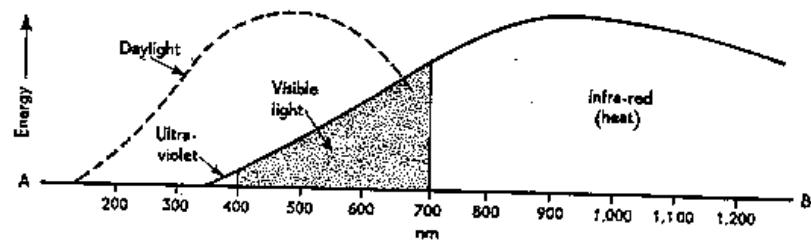


Fig. 2 Spectral power distribution of a gas-filled incandescent lamp

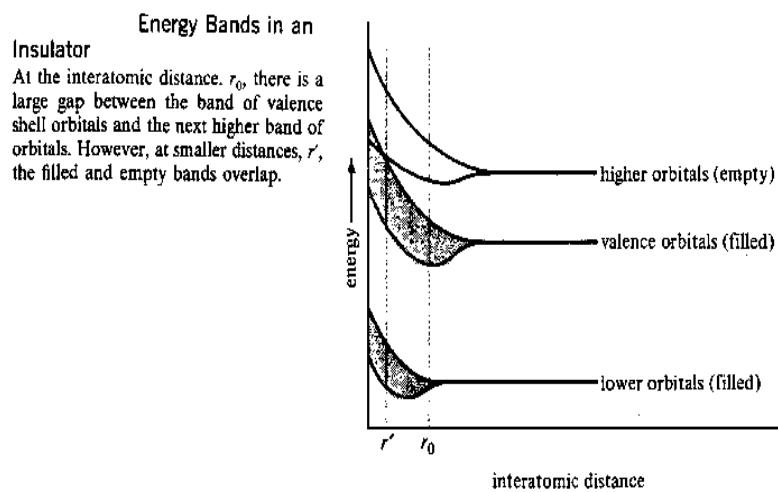
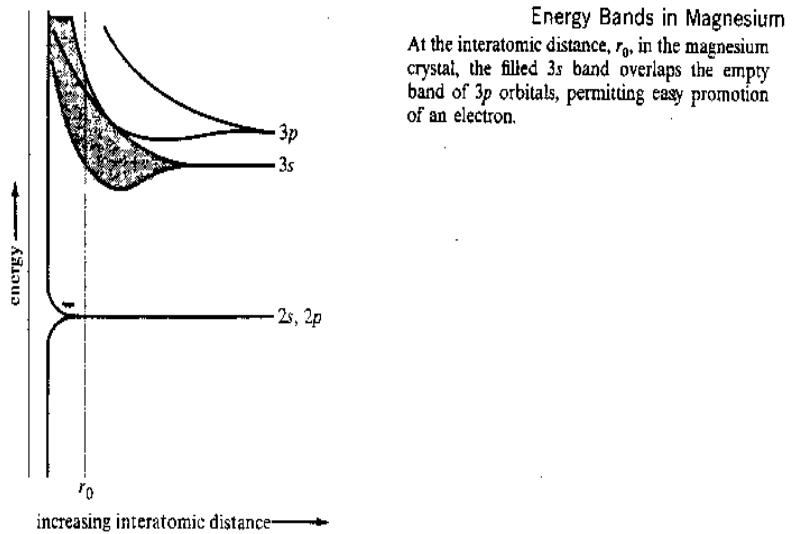


Fig. 3 Energy Bands in a Metal (ABOVE) AND AN INSULATOR (BELOW).

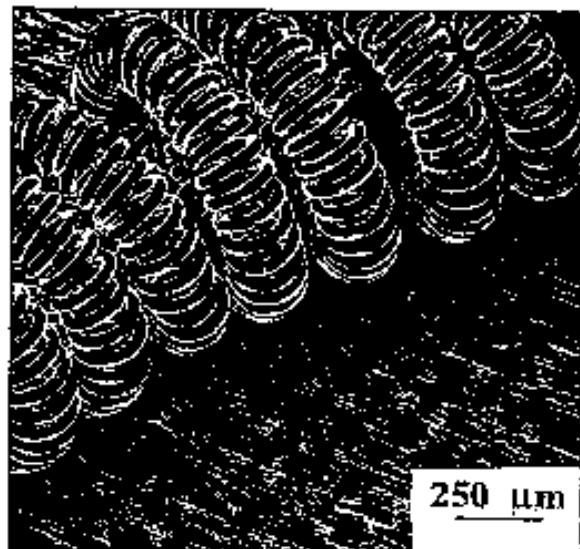
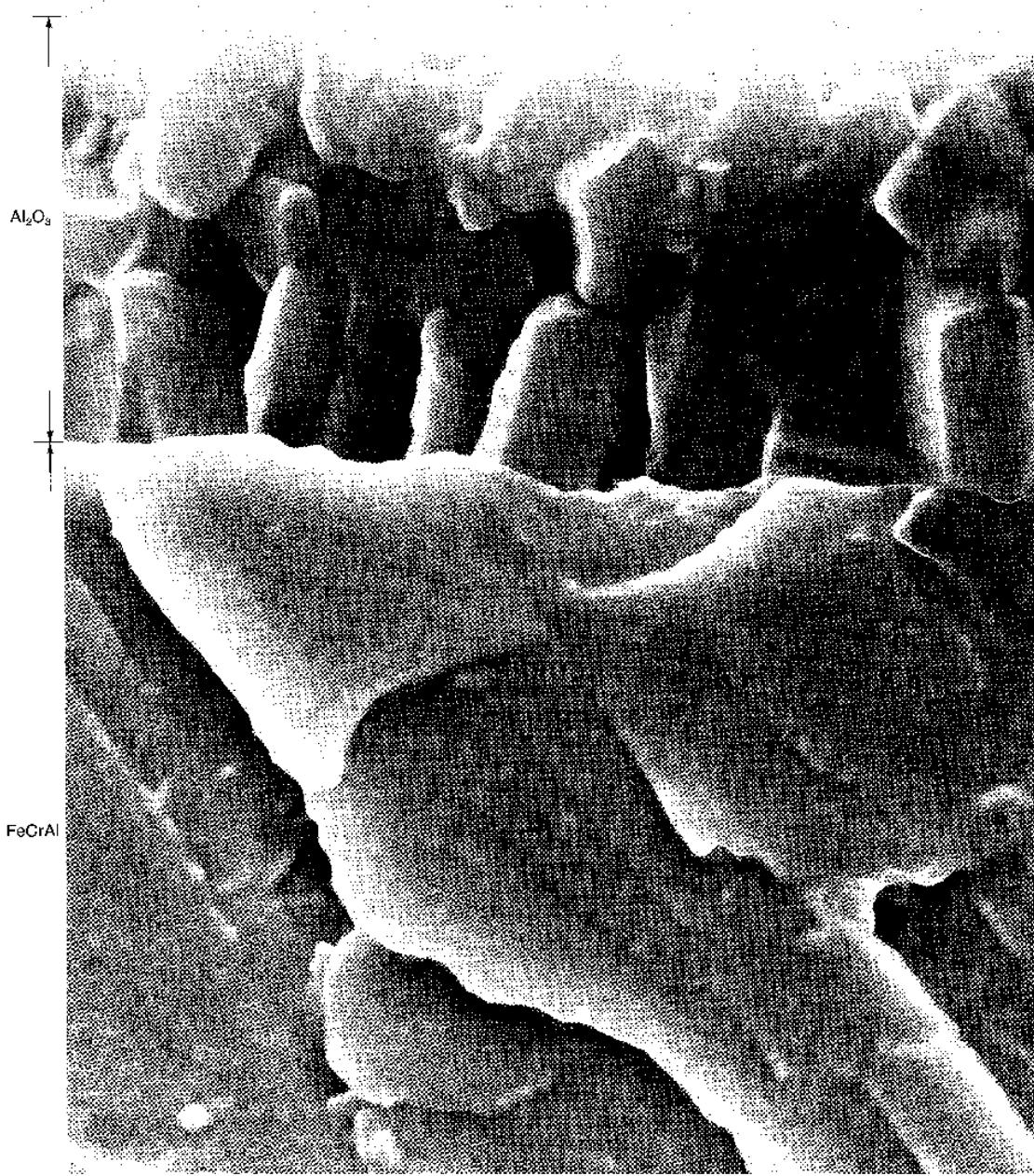


Figure 41 An example of a coiled-coil filament used in most incandescent lamps today. This figure shows an SEM micrograph of a section of filament that has been removed from the lamp.

Figure-5

Cross Section of KANTHAL Wire X 3000



UNITED STATES PATENT OFFICE.

THOMAS A. EDISON, OF MENLO PARK, NEW JERSEY.

ELECTRICAL LAMP.

SPECIFICATION forming part of Letters Patent No. 223,006, dated January 27, 1880.

November 4, 1879.

To all whom it may concern:

Be it known that I, THOMAS ALVA EDISON, of Menlo Park, in the State of New Jersey, United States of America, have invented an Improvement in Electrical Lamps, and in the method of manufacturing the same, (Case No. 188,) of which the following is a specification.

The object of this invention is to produce electric lamps giving light by incandescence, which lamps shall have high resistance, so as to allow of the practical subdivision of the electric light.

The invention consists in a light-giving body of carbon wire or sheets coiled or arranged in such a manner as to offer great resistance to the passage of the electric current, and at the same time present but a slight surface from which radiation can take place.

The invention further consists in placing such burner of great resistance in a nearly-perfect vacuum, to prevent oxidation and injury to the conductor by the atmosphere. The current is conducted into the vacuum-bell through platina wires sealed into the glass.

The invention further consists in the method of manufacturing carbon conductors of high resistance, so as to be suitable for giving light by incandescence, and in the manner of securing perfect contact between the metallic conductors or leading-wires and the carbon conductor.

Hitherto light by incandescence has been obtained from rods of carbon of one to four ohms resistance, placed in closed vessels, in which the atmospheric air has been replaced by gases that do not combine chemically with the carbon. The vessel holding the burner has been composed of glass cemented to a metallic base. The connection between the leading-wires and the carbon has been obtained by clamping the carbon to the metal. The leading-wires have always been large, so that their resistance shall be many times less than the burner, and, in general, the attempts of previous persons have been to reduce the resistance of the carbon rod. The disadvantages of following this practice are, that a lamp having but one to four ohms resistance cannot be worked in great numbers in multiple arc without the employment of main conductors of enormous dimensions; that, owing to the low resistance of

the lamp, the leading-wires must be of large dimensions and good conductors, and a glass globe cannot be kept tight at the place where the wires pass in and are cemented; hence the carbon is consumed, because there must be almost a perfect vacuum to render the carbon stable, especially when such carbon is small in mass and high in electrical resistance.

The use of a gas in the receiver at the atmospheric pressure, although not attacking the carbon, serves to destroy it in time by "air-washing," or the attrition produced by the rapid passage of the air over the slightly-coherent highly-heated surface of the carbon. I have reversed this practice. I have discovered that even a cotton thread properly carbonized and placed in a sealed glass bulb exhausted to one-millionth of an atmosphere offers from one hundred to five hundred ohms resistance to the passage of the current, and that it is absolutely stable at very high temperatures; that if the thread be coiled as a spiral and carbonized, or if any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber be so coiled, as much as two thousand ohms resistance may be obtained without presenting a radiating-surface greater than three-sixteenths of an inch; that if such fibrous material be rubbed with a paste composed of lamp-black and tar, its resistance may be made high or low, according to the amount of lamp-black placed upon it; that carbon filaments may be made by a combination of tar and lamp-black, the latter being previously ignited in a closed crucible for several hours and afterward moistened and kneaded until it assumes the consistency of thick patty. Small pieces of this material may be rolled out in the form of wire as small as seven-one-thousandths of an inch in diameter and over a foot in length, and the same may be coated with a non-conducting non-carbonizing substance and wound on a bobbin, or as a spiral, and the tar carbonized in a closed chamber by subjecting it to high heat, the spiral after carbonization retaining its form.

All these forms are fragile and cannot be clamped to the leading-wires with sufficient force to insure good contact and prevent heating. I have discovered that if platinum wires are used and the plastic lamp-black and tar

APPENDIX !

material be molded around it in the act of carbonization there is an intimate union by combination and by pressure between the carbon and platina, and nearly perfect contact is obtained without the necessity of clamps; hence the burner and the leading-wires are connected to the carbon ready to be placed in the vacuum-bulb.

When fibrous material is used the plastic lamp-black and tar are used to secure it to the platina before carbonizing.

By using the carbon wire of such high resistance I am enabled to use fine platinum wires for leading-wires, as they will have a small resistance compared to the burner, and hence will not heat and crack the sealed vacuum-bulb. Platina can only be used, as its expansion is nearly the same as that of glass.

By using a considerable length of carbon wire and coiling it the exterior, which is only a small portion of its entire surface, will form the principal radiating surface; hence I am able to raise the specific heat of the whole of the carbon, and thus prevent the rapid reception and disappearance of the light, which on a plain wire is prejudicial, as it shows the least unsteadiness of the current by the flickering of the light; but if the current is steady the defect does not show.

I have carbonized and used cotton and linen thread, wood splints, papers coiled in various ways, also lamp-black, plumbago, and carbon in various forms, mixed with tar and kneaded so that the same may be rolled out into wires of various lengths and diameters. Each wire, however, is to be uniform in size throughout.

If the carbon thread is liable to be distorted during carbonization it is to be coiled between a helix of copper wire. The ends of the carbon or filament are secured to the platina leading-wires by plastic carbonizable material, and the whole placed in the carbonizing-chamber. The copper, which has served to prevent distortion of the carbon thread, is afterward eaten away by nitric acid, and the spiral soaked in water, and then dried and placed on the glass holder, and a glass bulb blown over the whole, with a leading-tube for exhaustion by a mercury-pump. This tube, when a high

vacuum has been reached, is hermetically sealed.

With substances which are not greatly distorted in carbonizing, they may be coated with a non-conducting non-carbonizable substance, which allows one coil or turn of the carbon to rest upon and be supported by the other.

In the drawings, Figure 1 shows the lamp sectionally. *a* is the carbon spiral or thread. *c c'* are the thickened ends of the spiral, formed of the plastic compound of lamp-black and tar. *d d'* are the platina wires. *b b'* are the clamps, which serve to connect the platina wires, cemented in the carbon, with the leading-wires *x x'*, sealed in the glass vacuum-bulb. *e e'* are copper wires, connected just outside the bulb to the wires *x x'*. *m* is the tube (shown by dotted lines) leading to the vacuum-pump, which, after exhaustion, is hermetically sealed and the surplus removed.

Fig. 2 represents the plastic material before being wound into a spiral.

Fig. 3 shows the spiral after carbonization, ready to have a bulb blown over it.

I claim as my invention—

1. An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured to metallic wires, as set forth.

2. The combination of carbon filaments with a receiver made entirely of glass and conductors passing through the glass, and from which receiver the air is exhausted, for the purposes set forth.

3. A carbon filament or strip coiled and connected to electric conductors so that only a portion of the surface of such carbon conductors shall be exposed for radiating light, as set forth.

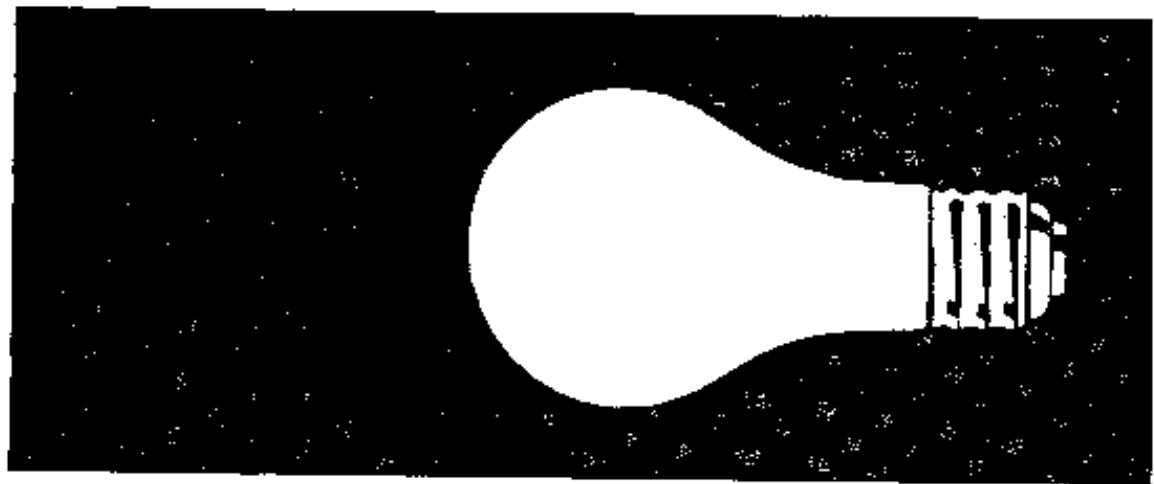
4. The method herein described of securing the platina contact-wires to the carbon filament and carbonizing of the whole in a closed chamber, substantially as set forth.

Signed by me this 1st day of November,
A. D. 1879.

THOMAS A. EDISON.

Witnesses:

S. L. GRIFFIN,
JOHN F. RANDOLPH.



...Its
parts
and
assembly

APPENDIX 2

THE
EXTRAORDINARY
LIGHT BULB



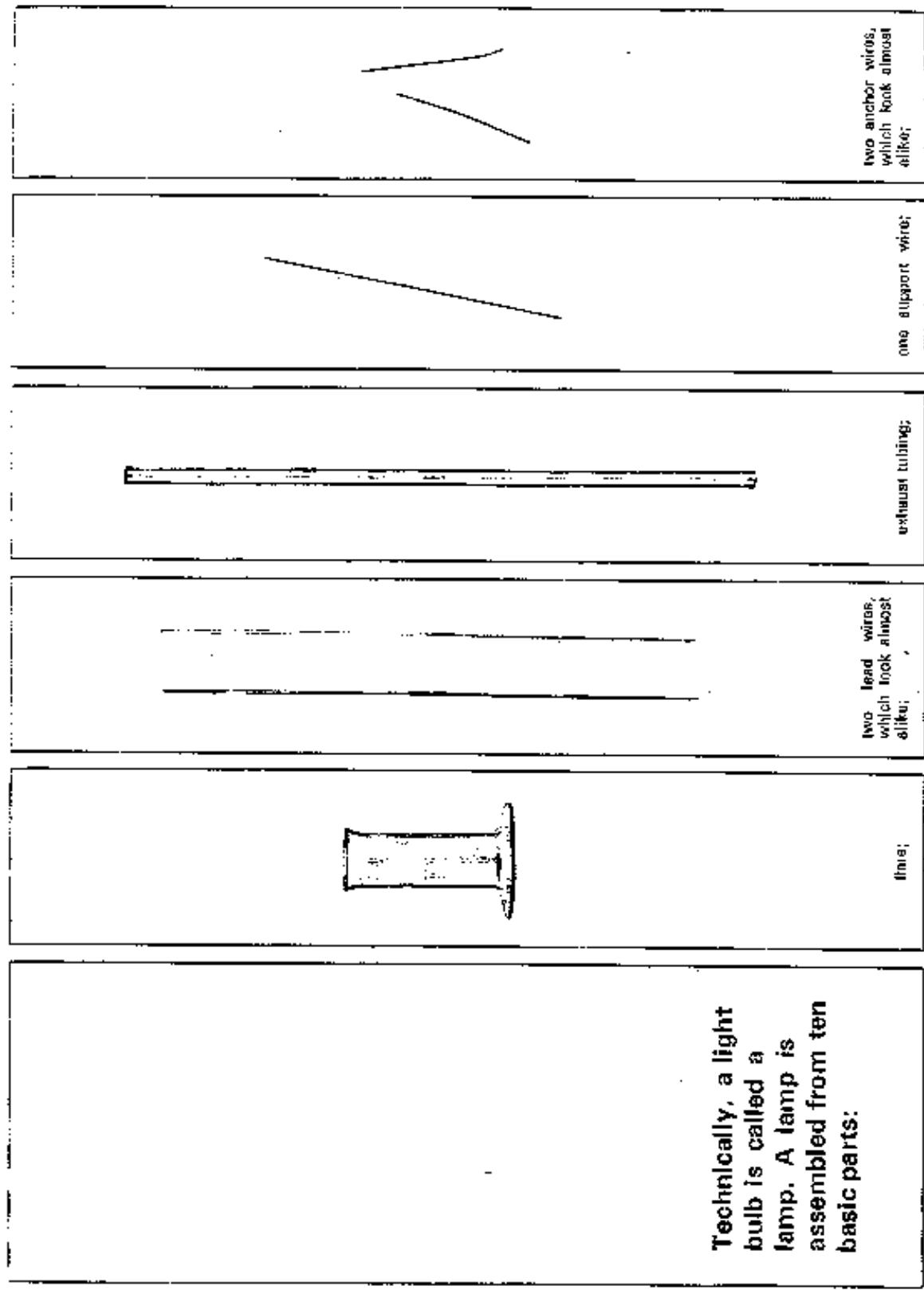
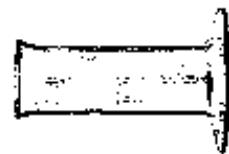
Technically, a light bulb is called a lamp. A lamp is assembled from ten basic parts:

three;

exhaust tubing;

one support wire;

two anchor wires,
which look almost
alike;



Though these parts are shaped and assembled entirely by machines, in order to give you a good look at the assembly process we will put one together "by hand."

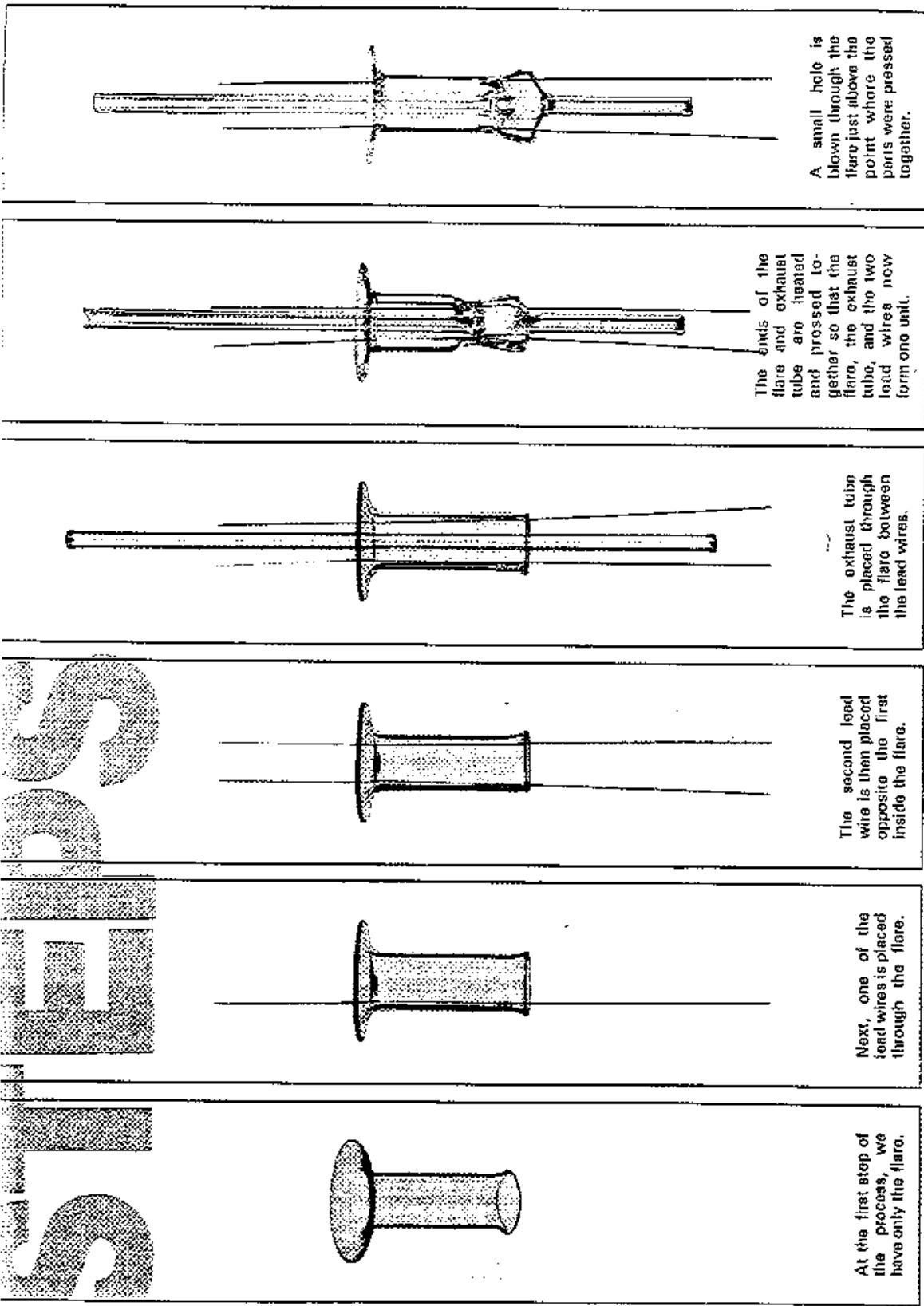


and base.



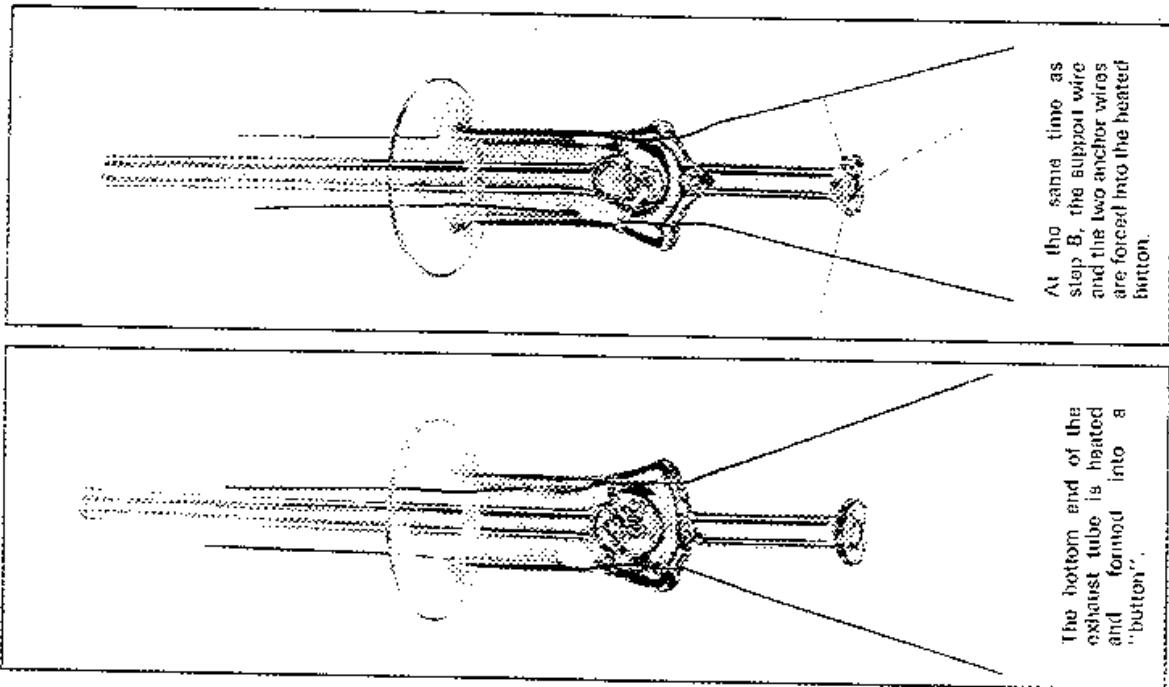
body

filament



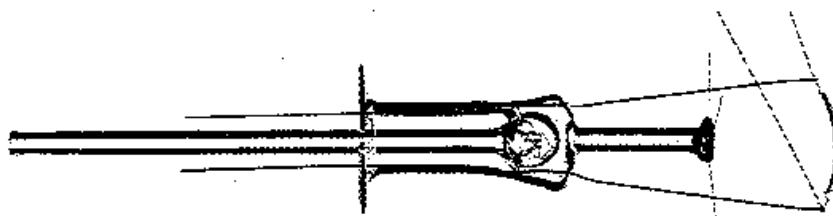
This completes
the stage of the
assembly which
is called the
'stem'.

Next . . .



At the same time as step B, the support wire and the two anchor wires are forced into the heated button.

The bottom end of the exhaust tube is heated and formed into a 'button'.



The ends of the filament
are placed in the open
hooks on the lead wires.



The lead wires are
slightly stretched and
spread apart.

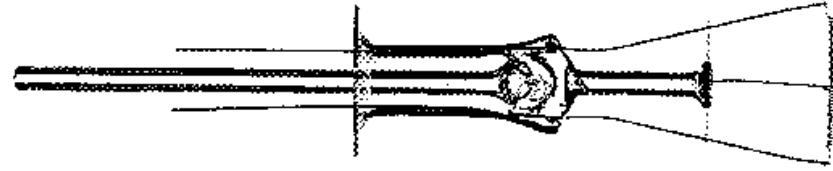


A small hook is formed
at the end of each lead
wire.

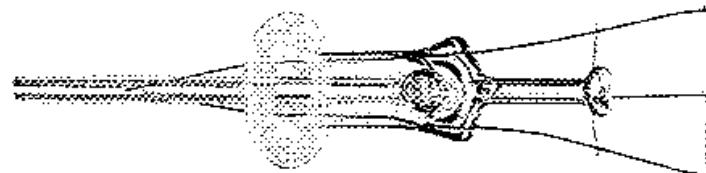


The lead wires are cut
off.

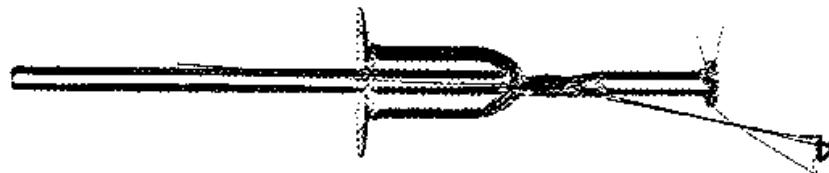




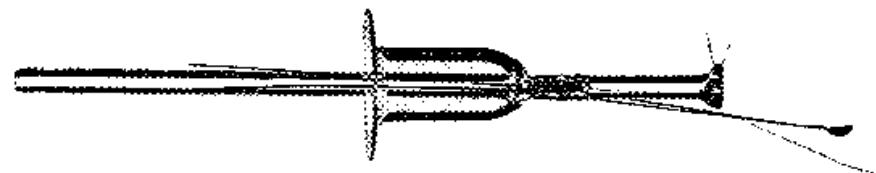
The lead wires are bent inward above the anchor wires, so that the ends of the lead wires are properly spaced.



The ends of the anchor wires are formed in loops around the lead wires.

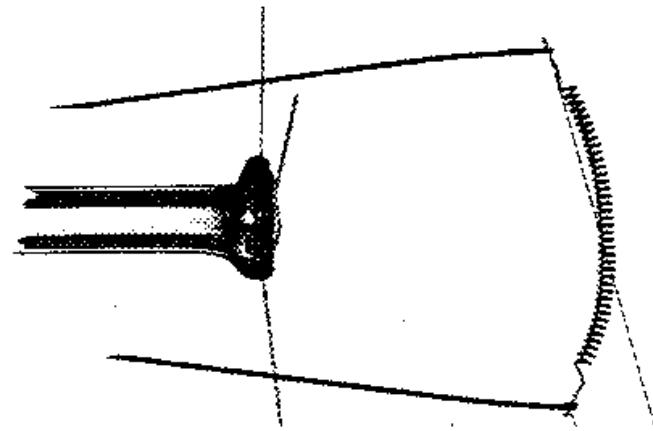


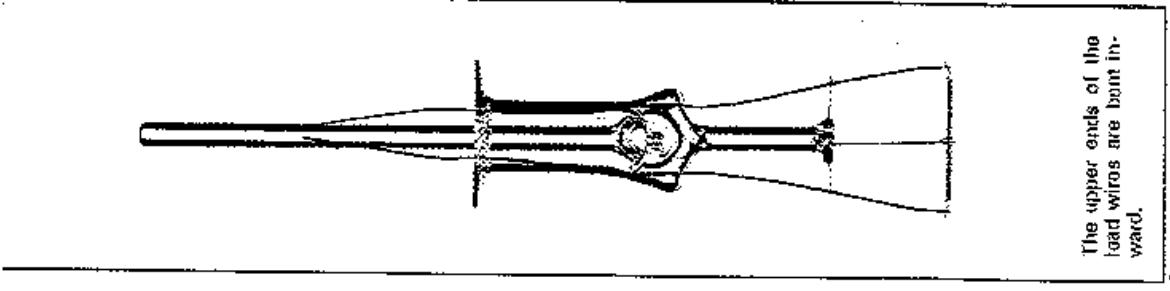
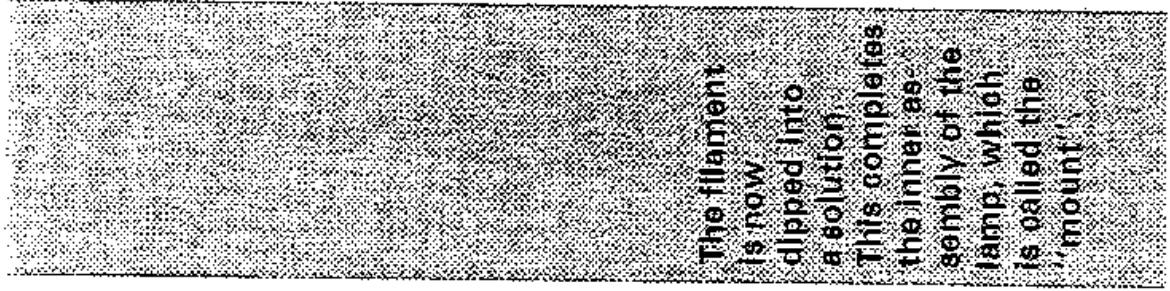
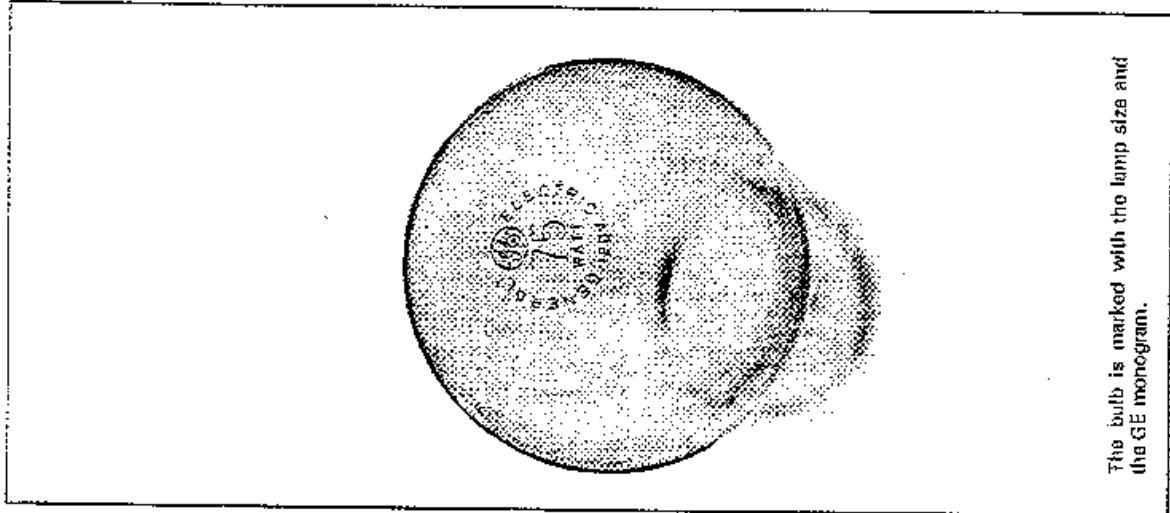
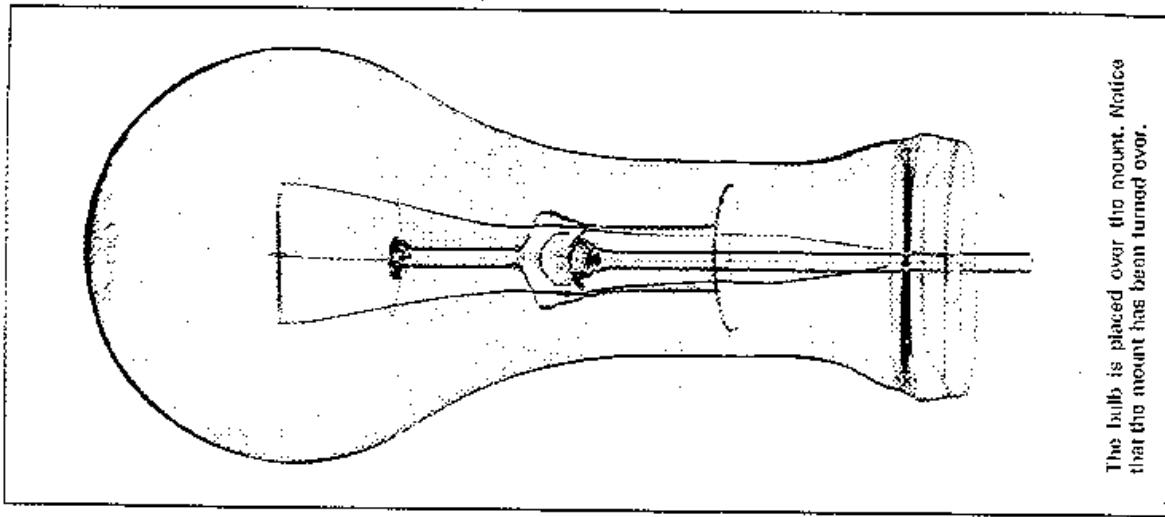
The end of the support wire is formed in a loop around the filament.

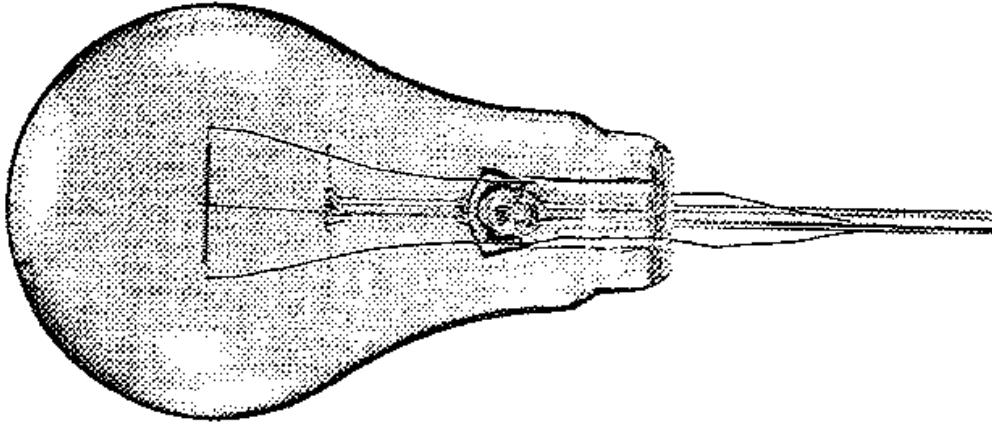


While these hooks are being closed, the support wire is bent down toward the filament.

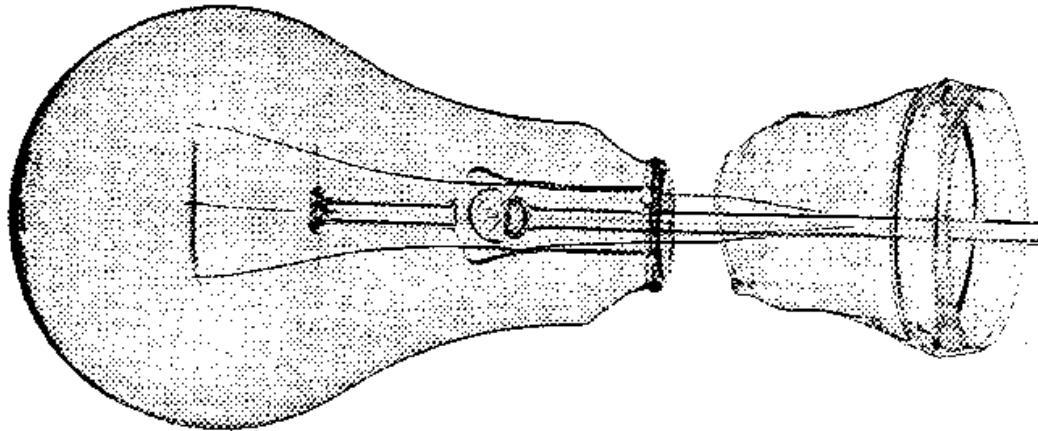
Thus a hooks are closed.



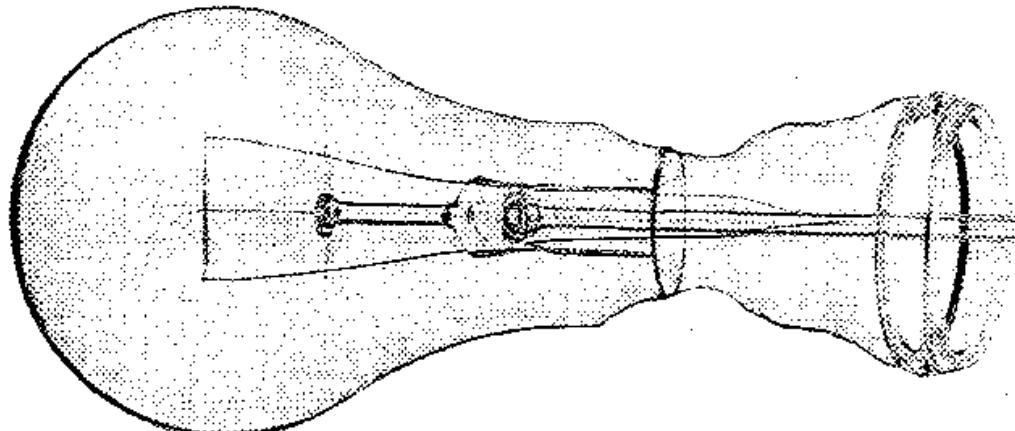




The bottom of this assembly is molded, while under heat, to fit the base.

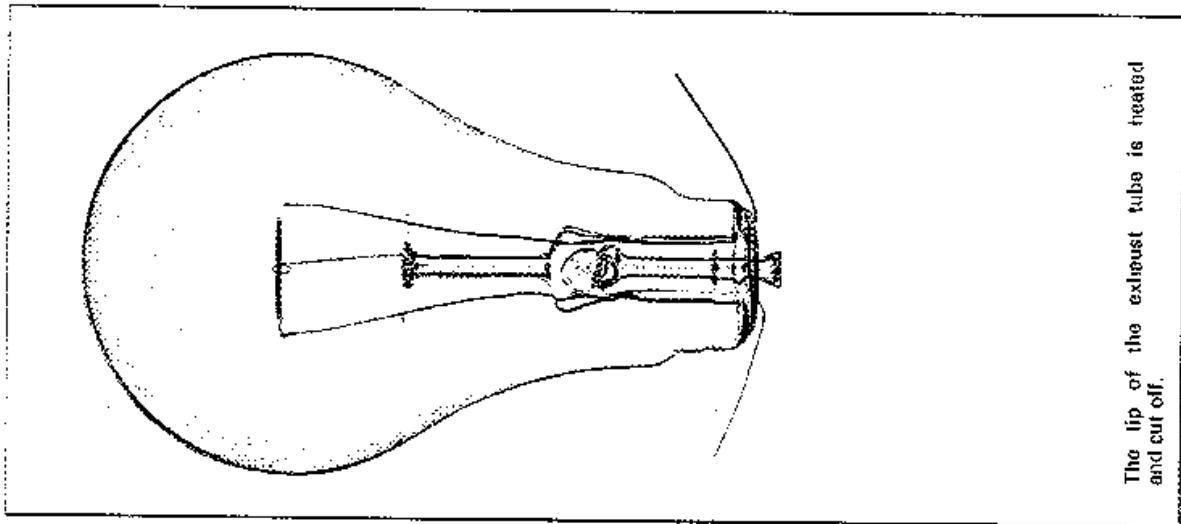


The part of the bulb below this joint is heated and cut off.

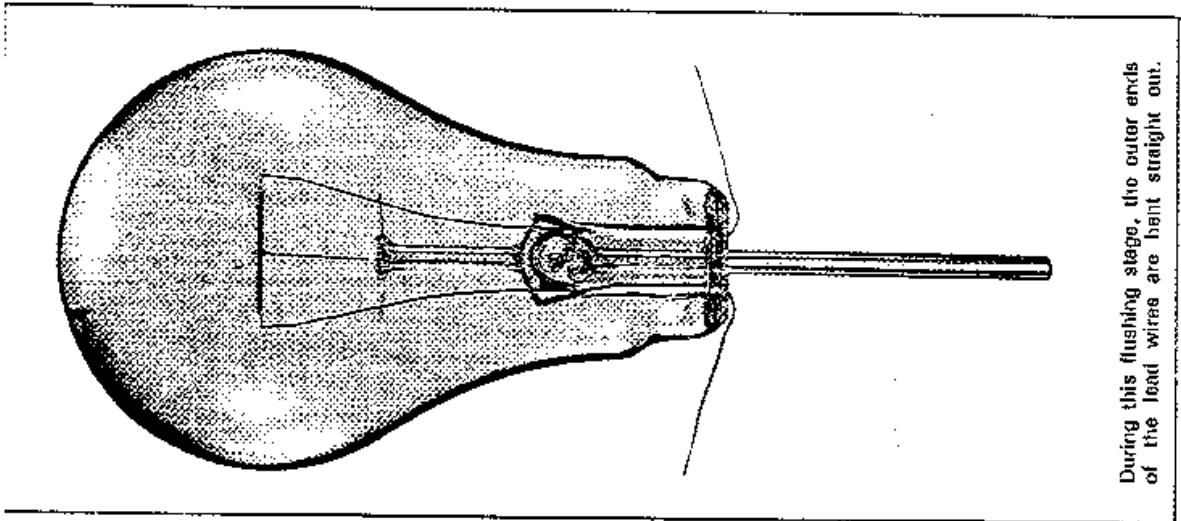


The neck of the bulb and the bottom of the flare are heated and joined.

At this point,
the assembly is
called an
unbased
lamp.
It could
actually be
lighted



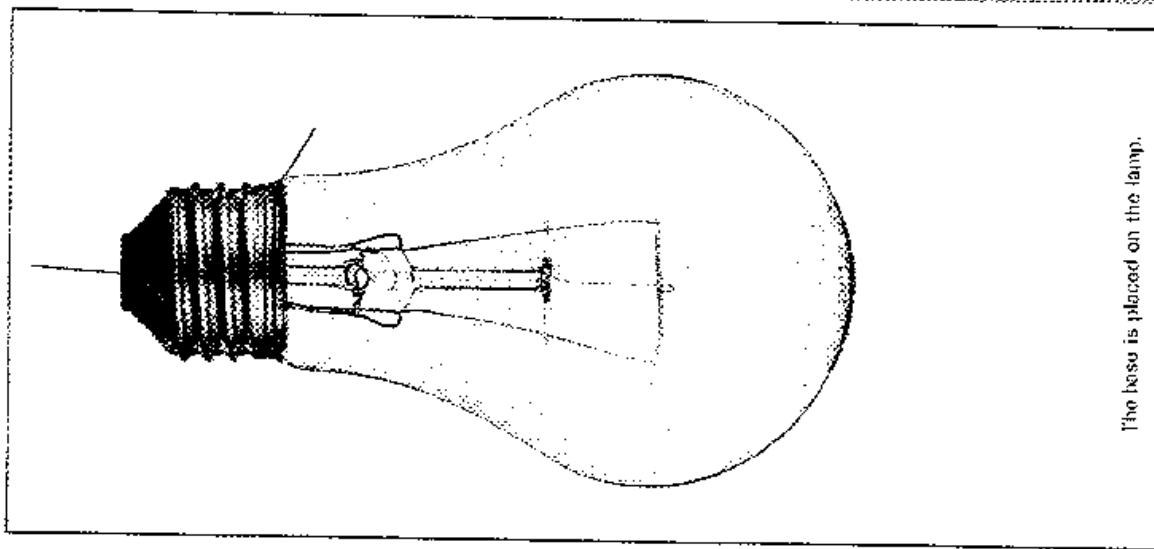
The tip of the exhaust tube is heated
and cut off.



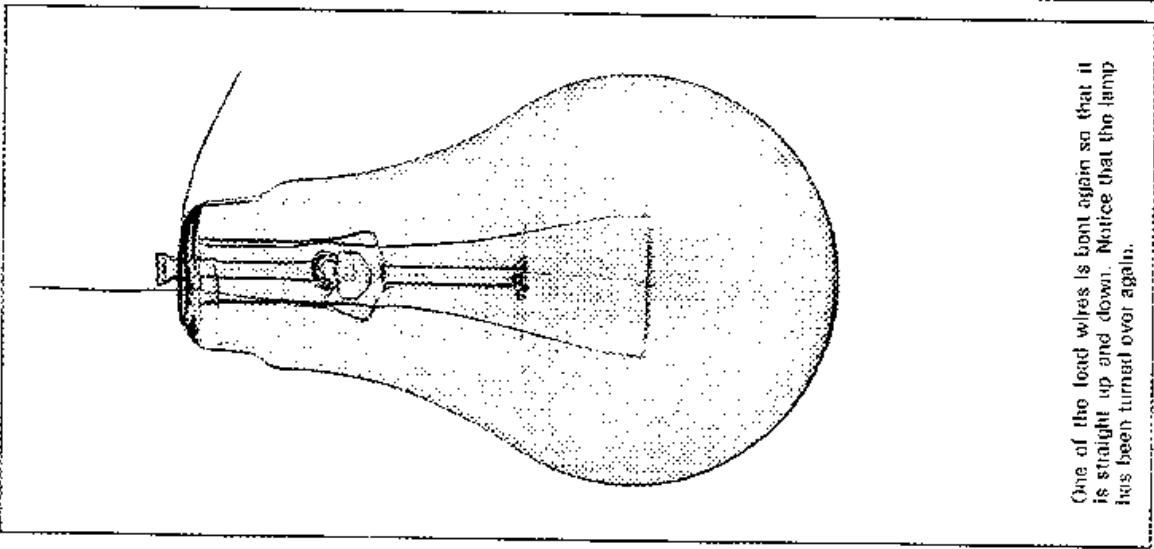
During this flushing stage, the outer ends
of the lead wires are bent straight out.

The coil is
now removed
through the ex-
haust tube,
and the bulb
is flushed out
with a gas.
Another gas is
then forced
into the bulb.

The base is now baked on
and a kind of oil is
applied to the threads of
the base

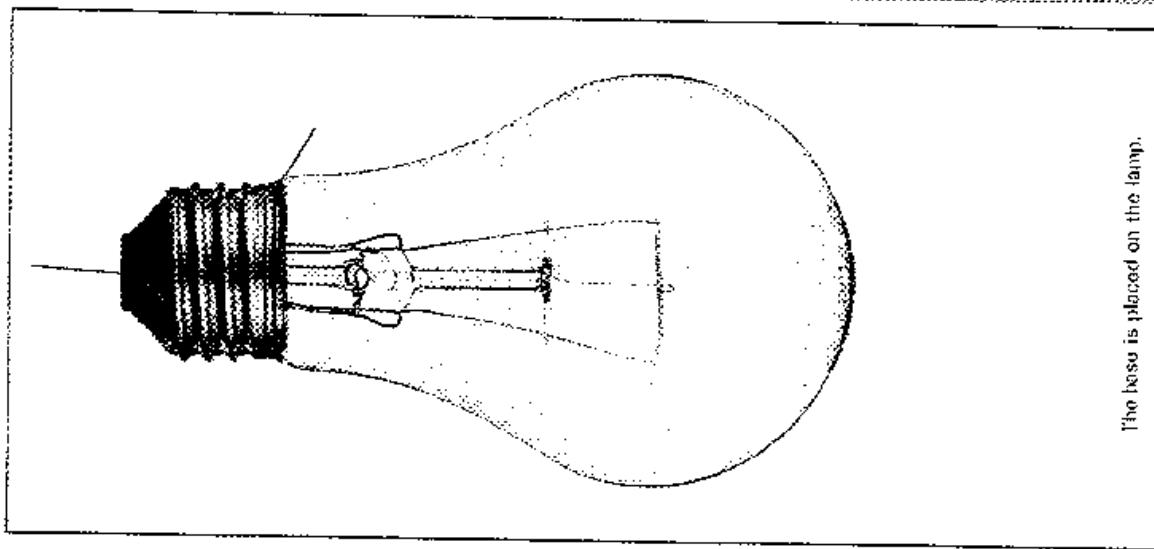


The base is placed on the lamp.

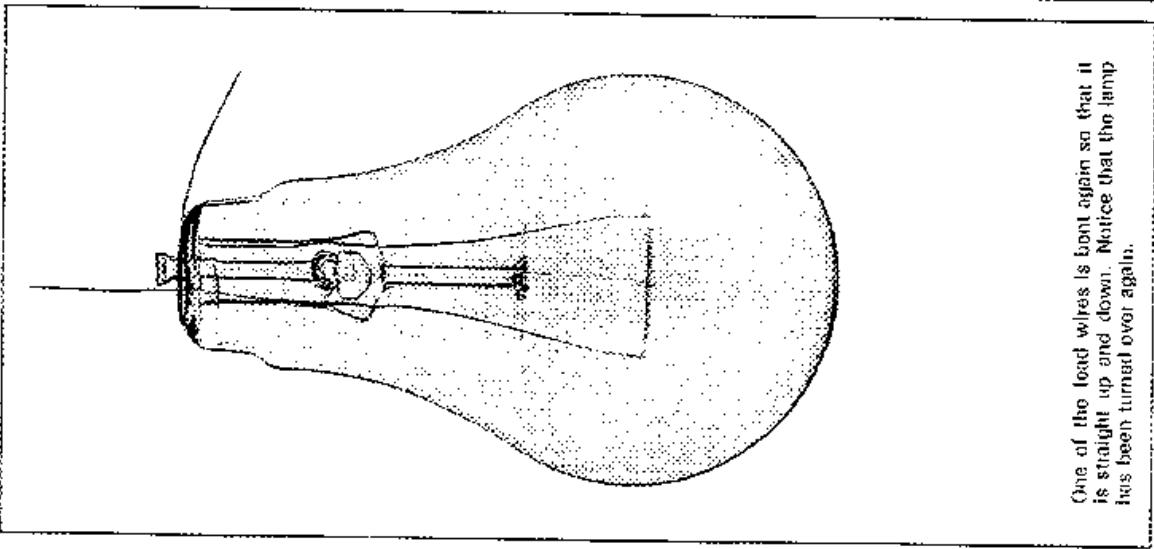


One of the lead wires bent again so that it
is straight up and down. Notice that the lamp
has been turned over again.

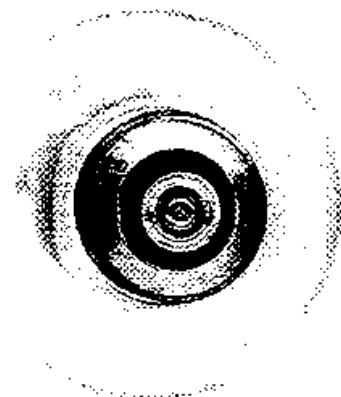
The base is now baked on
and a kind of oil is
applied to the threads of
the base



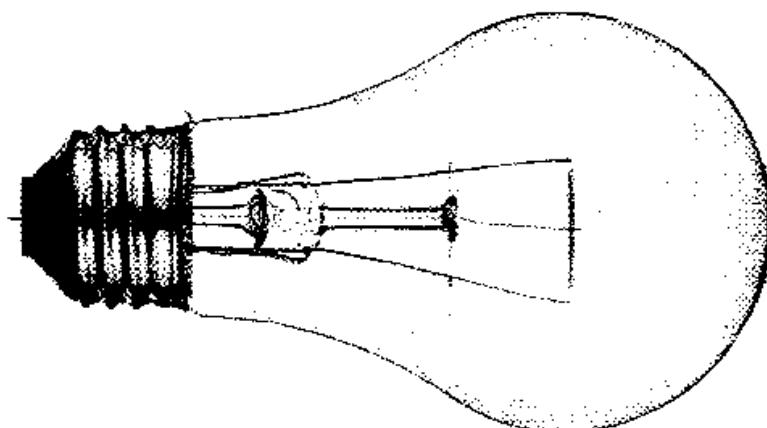
The base is placed on the lamp.



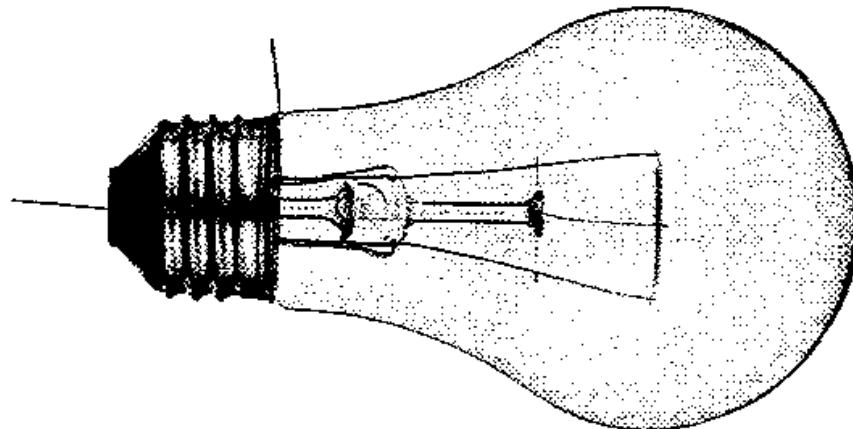
One of the lead wires bent again so that it
is straight up and down. Notice that the lamp
has been turned over again.



The lead wire passing through the end of the base is flattened and a drop of "flux" is put on the end of the bus.

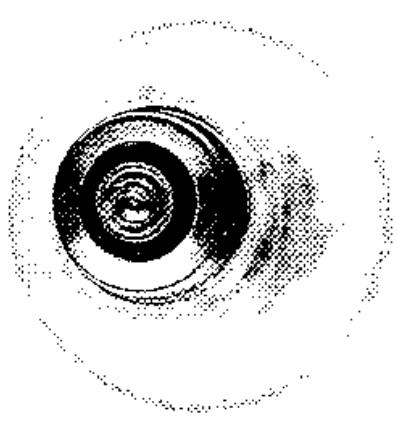


The ends of the lead wires are cut off.

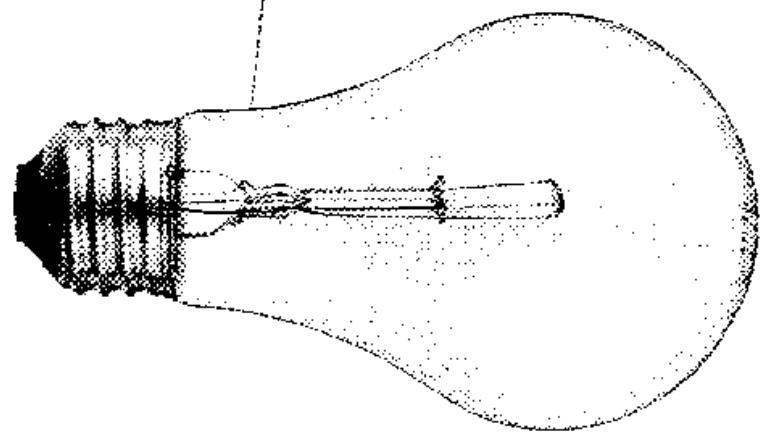
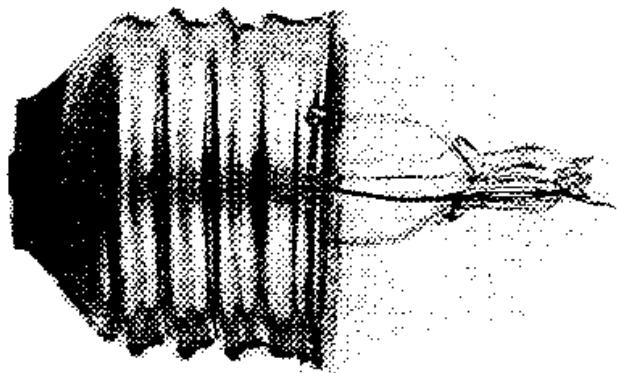


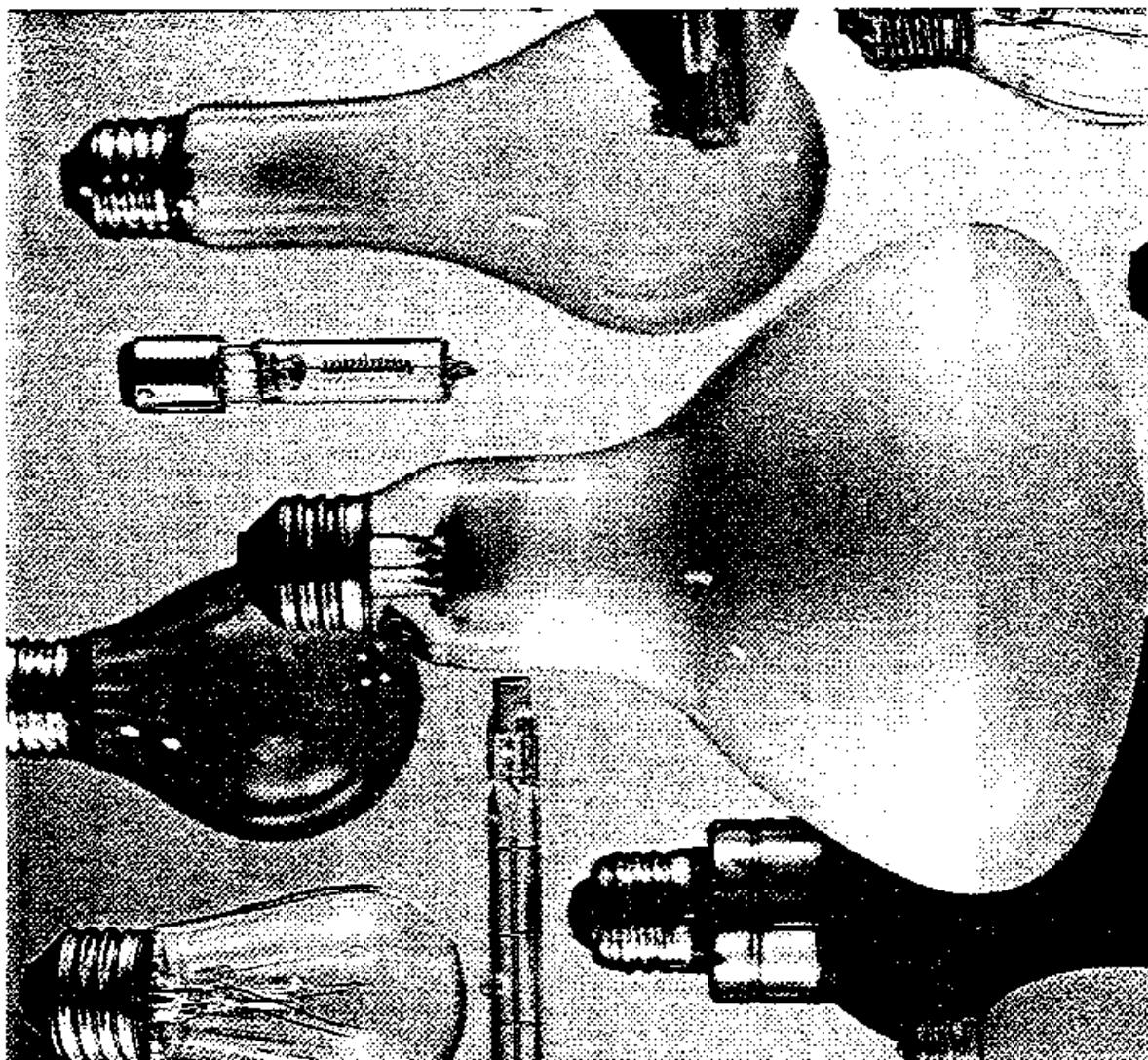
One lead wire is bent straight out and the other straight up.

The end of the lead wire passing through the
end of the base is soldered.



The end of the lead wire on the side is welded to the base.





The filament is now
"aged" by lighting the
lamp. The lamp is then
tested for quality.
This completes the
assembly of the lamp.

THE LIGHT BULB: PRECISION INSTRUMENT

Today's incandescent light bulb has little in common with Edison's 1879 light. It comes in hundreds of sizes, shapes, finishes, colors, with a wide variety of electrical and performance characteristics. It has countless applications.

Take just one ... the popular 100-watt household bulb. About 300 million are made in this country each year. In such numbers what could be more commonplace than a bulb of glass, metal and glass? But if the bulb is commonplace, it is far from ordinary.

The glass used in bulbs is especially designed to transmit maximum light, strong enough to withstand temperatures varying from below zero to 850 degrees, rugged enough to withstand rough handling.

To assure these characteristics, General Electric produces its own bulbs from a special, chemically pure sand, joined with soda ash and limestone in furnaces at 2050° Fahrenheit.

HEART OF A LIGHT BULB:

The most critical part of a light bulb is its filament. This part glows white-hot and produces light when electricity passes through it. The filament is tungsten, with a higher melting point than any other metal. It's a rarer metal than gold or platinum, rarer than uranium!

Again General Electric starts with raw material ... tungsten ore right from the mine. This is reduced to powder, purified, pressed, heated, hammered, drawn through diamond dies until it is a strand as thin as a human hair. For some smaller bulbs, the wire is so fine that its diameter cannot be determined accurately by regular measuring techniques. The effective thickness is reached by weighing a precisely defined length of wire.

In early bulbs, filaments contained only three large loops. GE lamp engineers learned that the more coils in a length of wire the more light it produced per watt. Today's lamp filament is tightly coiled ... 850 times. Then this coiled wire is itself coiled again. The coiled-coil design was developed in General Electric laboratories.

No part of a light bulb is manufactured with more care than its vital tungsten filament. Each one has been closely inspected by the operator of a projection microscope, has been subjected to 20 different tests. Coils out of line as little as 1/10,000 of an inch are rejected.

Early light bulbs operated in a vacuum that kept the filament from evaporating rapidly. GE found that by operating the filament in inert gases, it could retard the evaporation further.

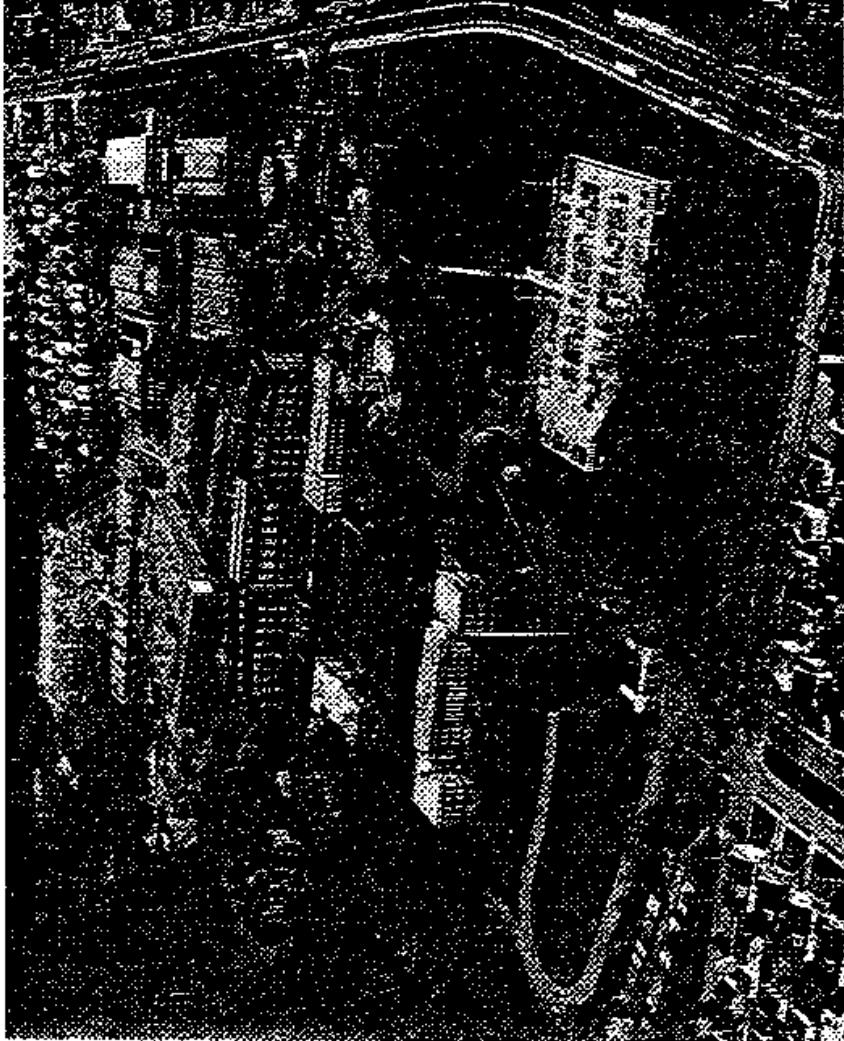
ASSURING BULB QUALITY

A bulb's atmosphere must be spectroscopically pure. One ten-millionth of a per cent of impurity can adversely affect a lamp's operation. General Electric produces its own gases ... argon and nitrogen ... for incandescent bulbs through a process called "fractional distillation of air." The gas lets the filament operate at temperatures close to melting point ... 6170° Fahrenheit ... with minimum evaporation.

Other components of a bulb ... molybdenum wires to support the filament, Dunnet wire leading electric current into the bulb, internal glass parts, threaded aluminum base which fits a variety of new and old sockets ... all must be made with the same care before the finally assembled bulb, after many inspections and tests, is lighted and placed in its package. So, although a light bulb is commonplace, it is anything but ordinary!

Nela Park is the national headquarters and the research and development center of the General Electric Company's Lamp Division. The first of this country's industrial parks, Nela Park was established in 1913 on a plot of land that since has grown to 92 acres, in East Cleveland, Ohio, nine miles from downtown Cleveland.

Here sweeping lawns, ivy-clad Georgian buildings and ornamental trees and shrubs create the atmosphere of a college campus. It is not surprising that this world headquarters of lamp and lighting progress is frequently called "The University of Light." But Nela Park is more than lawns, buildings and trees; it is people. It is a research scientist experimenting with a new light source for tomorrow, a specialist refining the production techniques of today, an engineer developing a more effective lamp application, a lighting educator demonstrating the world of illumination. Nela Park blends people and products into a responsive combination designed to serve people at work, at home and at play.



LAMP DIVISION

GENERAL ELECTRIC

1112-9182