GENERAL ELECTRIC
"HOUSE of MAGIC"



The General Electric

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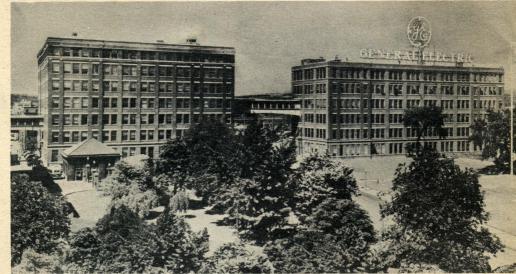


GENERAL @ ELECTRIC



# THE GENERAL ELECTRIC RESEARCH LABORATORY

PAST—The Laboratory's birthplace was this barn behind the Steinmetz home.



PRESENT—Home of the Laboratory today are these buildings in Schenectady.



FUTURE—Upon completion of these buildings near Schenectady, G-E research will be given a "scientist's paradise" in which to continue their search into the unknown.

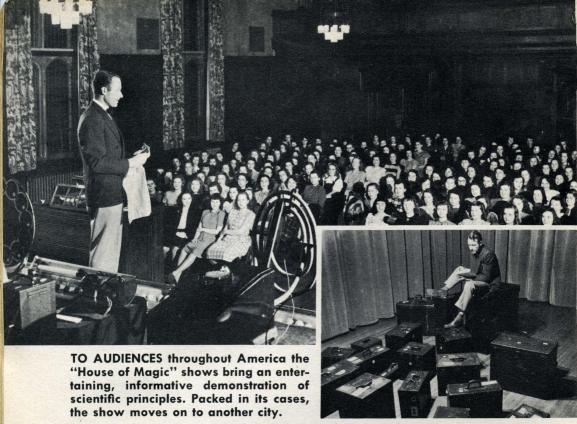
#### · Out of the Research Laboratory

On a summer day in 1930 the late Floyd Gibbons—he of the white eyepatch and the rapid-fire voice—came, as many visitors had done before him, to see the General Electric Research Laboratory in Schenectady. Walking through the Laboratory's workrooms he found his curiosity kindled by the sight of powerful x-ray devices, by early experiments in television, even by such things as faucets that, instead of tapping hot or cold water, poured out oxygen, hydrogen and acetylene gas. Later, in a special "guest room" he was amused when scientists, relaxing for a moment from their more serious work, showed him the bones of his hands by means of x-rays, popped corn with radio waves, and used "electric eyes" to open doors at the wave of a hand. "This," Mr. Gibbons told his radio audience that night, "is truly a House of Magic."

In this way a name was found for an idea that had been developing in the Laboratory for some time. The idea was that people like to see scientists at work—that the experiments, the equipment, the demonstrations by which scientists explain their projects to each other could be made into a show that people would find not only instructive, but amusing and interesting as well.

The idea was put to its first big test in 1933. For the Chicago Fair, "A Century of Progress," General Electric staged some of its more spectacular developments in a little theater designed especially for the show, assigned speakers to describe the demonstrations in a light and clever way, and called it the "House of Magic." During the two years of the Fair, the show was seen by more than a million people. It has since been shown at every major world's fair.

Although originally the name "House of Magic" was given to the whole G-E Research Laboratory, it now invariably refers to the science shows which have sprung out of Laboratory discoveries. These units have played in every state of the Union and in several provinces of Canada. During the war, 2,308 shows were shown to approximately 1,200,000 soldiers, sailors, and marines. All in all, over 12 million people have seen the "House of Magic."



# A glimpse into Research

When early visitors to the General Electric Research Laboratory saw such things as "electric eyes" and "artificial fever" machines, they might readily have believed that they were seeing magic and sleight-of-hand. Actually, however, they were observing simply a few of the more novel and unusual aspects of science. "House of Magic" shows still follow this principle. Their magic is never deception. Even "The Man Who Shakes Hands with His Shadow" is not a trick, but a demonstration of a scientific fact. Each act of the show is—as the speaker always points out—"the truth of science as nearly as nature has revealed it to us."

Even though the "House of Magic" has left the Research Laboratory and has gone out to audiences all over the country, it maintains close ties with the Laboratory and from time to time adds new demonstrations based on Laboratory projects. It offers, essentially, a glimpse into some phases of the Laboratory's work. Through the "House of Magic" shows, people all over America still, in effect, take tours of the workrooms of science.

### "Bouncing Putty" — The Silicones

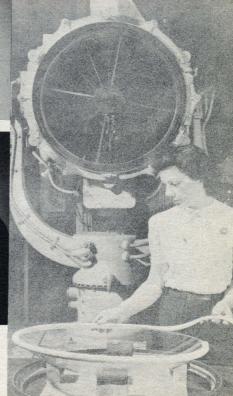
As the opening demonstration of the "House of Magic" show, the audience sees a sample of the silicones—new and versatile substances developed by Research Laboratory chemists. Silicon, the basic constituent of these substances, is one of the most common of the chemical elements, yet only in the last few years has science begun to realize its possibilities. From the Laboratory have come silicone oils that continue to run free at temperatures so low that other oils become sluggish, and silicone rubber that stays elastic at low temperatures, when natural rubber becomes hard and brittle, or at high temperatures, when natural rubber melts. Already silicone rubber is finding uses in aircraft superchargers; the oils are used in hydraulic systems; and silicone resins insulate transformers.

The silicone seen during the show is an amusing by-product of the Laboratory's research. A substance called "bouncing putty," it can be pulled like taffy and kneaded like bread dough, yet when rolled into a ball it bounces as high as rubber.





KNEAD IT like dough, bounce it like rubber—that's bouncing putty. Other silicones are finding many applications where temperature conditions are tough.



#### · Artificial Fever

One of the pieces of apparatus on the "House of Magic" stage is a black coil connected to a metal box. This is the inductotherm. When this device is turned on, nothing happens that you can see. But a great deal of unseen action is taking place. The inductotherm is filling the surrounding air with invisible waves and will cause electric current to flow through anything brought near it. Enough current will, as the lecturer proves, flow through a loop of wire to light a lamp. He can light it just as readily by making a loop of his arms and holding the lamp in his fingers.

The speaker cannot feel the current passing through his arms, but he does feel the heat it produces. Several years ago Dr. Whitney became interested in this phenomenon and determined that these waves could be used to induce an artificial fever in human beings. Doctors, believing that the body develops a fever in order to "overheat" disease germs and kill them, showed great interest. Today models of the inductotherm similar to that used in the show are standard equipment in hospitals throughout the country.



THE INDUCTOTHERM, by creating a magnetic field around its coils, can force current through a man's arm to light a lamp. The device is used in hospitals to induce artificial fever.





#### The Radio Rainbow

When the "House of Magic" speaker picks up an apparently empty glass tube and holds it near the inductotherm, the tube begins to glow. Brought still closer, it gives off a brilliant blue light. Yet the tube has no wires attached to it.

The explanation, again, lies in the invisible high-frequency waves being transmitted from the fever machine. The strange blue light results when these waves pass through mercury gas sealed in the tube.

Each tube that the lecturer holds near the inductotherm bursts into a different color—one red, one green, another violet, making a dazzling "radio rainbow." The reason is that each tube is filled with a different gas, which gives off its own characteristic hue.

But in addition to giving off a visible glow, these gas-filled tubes send out invisible ultra-violet rays. This fact has also been put to practical use. When certain chemicals called phosphors are exposed to ultra-violet rays they will "fluoresce"—that is, they will transform the invisible wave lengths into visible light. The combination of the principle of the glowing tubes of the radio rainbow with the principle of fluorescence has given us today a new kind of light—the soft, white light of the fluorescent lamp.





#### These gears don't need to mesh

It seems almost axiomatic that if one gear is to turn another, it first has to touch the other gear, has to "mesh" with it. Not so the metal gears shown above. Spin the one on the left and—magic!—the one on the right will spin, too, even though its teeth are several inches away.

The secret is that behind each of the "House of Magic" gears are bars of Alnico V, the powerful magnetic material developed in the Research Laboratory. You have seen how a bit of iron will leap to a horseshoe magnet. Perhaps you have seen how two similar magnetic poles will push each other away.

The teeth of the Alnico gears are of the same polarity. They push against each other. In the picture you see the tooth of the right gear projecting between two teeth of the left gear. The magnetic flux of the top tooth is pushing down on it, and the flux of the lower tooth is pushing up against it. That tooth, therefore, is held in its position almost as surely as if the metal were touching. But when the speaker shoves the left gear, this balance is broken. The top tooth shoves down its magnetic field, pushes the tooth of the other gear away from it, and both gears turn.

A practical application of these gears may be found in many aircraft gasoline gauges today. An Alnico gear *inside* the tank turns another *outside* it, thus removing the fire hazard that goes with a joint.

#### Recording on Wire

With the General Electric wire recorder, magnetism—which was used to mesh the Alnico gears across the way—takes on another task, that of trapping sound on wire. The recorder can wrap more than an hour of constant chatter or serious debate onto one small roll of steel wire.

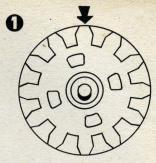
Just as readily it can wipe the entire hour off the wire and give you back your spool as good as ever!

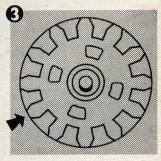
The recorder does not cut grooves into the hair-like wire. A special recording head forms an invisible magnetic pattern on it, a pattern that will reproduce the sound when the wire is played back through the recorder, or that may be erased completely by demagnetizing the wire.

The magnetic wire recorder has found spectacular as well as everyday uses. At Saipan the Marine Corps recorded over seven hours of on-the-spot description of the Americans' invasion. The small picture below was taken as a correspondent described the surrender of a German U-boat. More peacefully, the recorder is widely used in the radio and entertainment field, in education and for innumerable specialized tasks.









#### Motionless motion

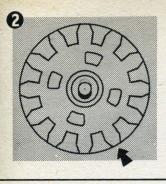
HOW THE STROBOSCOPE LAMP "STOPS up the wheel as in figure 1. Before the flashed off again. It remains off as the wagain approaches its original position, the catching the wheel in exactly the same a seen as a blur in ordinary light, seems to

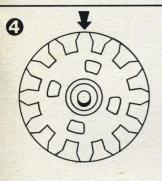
We have seen earlier how electric waves passing through sealed-in gases will make them glow. The scientist has found an interesting thing about this phenomenon. When the electricity is turned off, the glow stops <code>instantly—</code> in contrast with the ordinary incandescent lamp, whose wire filament more or less takes its time about going out.

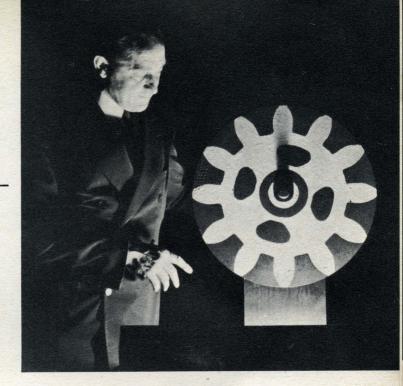
The scientist has put this little quirk of the gas-filled lamp to effective use. With a lamp that is giving a bright flash of light one instant, and absolute darkness the next—with the *stroboscope lamp*, he can make even a whirling airplane propeller seem to stand still.

The "House of Magic" speaker demonstrates stroboscopic lighting by doing tricks with a wheel painted to represent a gear. A small electric motor turns the wheel fast enough that in ordinary light it seems only a blur. Then the light is turned off and the stroboscopic lamp turned on. Instantly the wheel seems to stop. We see its pattern sharply outlined. Yet we know that it is actually rotating at high speed. A piece of paper held against the seemingly motionless wheel is thrust noisily away.

The secret lies in timing the lamp's flashes exactly with the wheel's revolutions. With this arrangement, the gear is in the same position every time







'MOTION.—The lamp flashes on, lighting wheel can move perceptibly, the lamp has leel spins around in darkness. As the wheel lamp flashes on a second time, as in figure 4, osition as before. Thus the speeding wheel, stand still.

the light flashes. Each flash is of such short duration (five millionths of a second or less) that the wheel scarcely has time to move before the light is out, out completely, with no lingering rays to follow the wheel's progress. The wheel spins around in absolute darkness. At the exact split-second when it is in the same position as during the preceding flash, the light ticks on again and reveals the wheel to us. All this happens so fast that our eyes cannot detect the individual flashes and are fooled into believing that the wheel is standing motionless.

The stroboscopic lamp has many applications in industry. Since the engineer can vary the speed of the light flashes to match the speed of any rapidly rotating machine, he can study the action of machines while they are operating as high as 50,000 revolutions per minute, thus enabling him to make better and safer designs.

Also, a wide variety of uses is being found now for stroboscopic pictures of motion. If a golfer's swing, for example, is photographed in stroboscopic light, the finished picture will show the club at various stages of the swing—caught by the light's quick flashes. This process is used in the laboratory to photograph fast-moving mechanical parts.

#### The train that obeys spoken commands

"Back up," says the speaker. The electric train immediately rolls away from him. "Stop," he commands, and it stops. When he says "Come here, please," the train obediently returns.

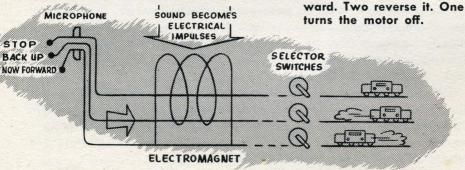
A trick, definitely. But a trick that differs only in novelty from the magic you bring about whenever you use a telephone or listen to a radio.

With his obedient electric train, the "House of Magic" speaker demonstrates one of the electric fundamentals: control—the secret of turning electricity on and off. Scientists have found ways of controlling electricity by magnetism, chemical action, light, sound, even the approach of a body. The electric train is a demonstration of control by sound.

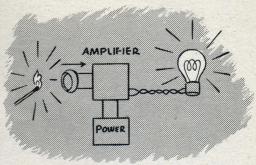
The train can't understand the speaker, but it is able to count the number of syllables. Three syllables—"Come here, please"—make it come forward. So will "Come on, now" or "Fe fi fo." But when only two syllables are transformed into electrical impulses, a different switch is closed in the train and the machinery is reversed. A single syllable turns the motor off altogether, and the train stops.

THE TRAIN'S SECRET is that special equipment transforms sound into electrical impulses. Three syllables become three impulses, making the train move for-









IF YOU HAVE A PHOTOTUBE, the trick is easy. The phototube "sees" the match's light and passes current. This current, after passing through a small amplifier, actuates a relay, causing the lamp to light.

#### Lighting an electric lamp with a match

In the laboratories of General Electric many practical and important uses have been found for the phototube, or "electric eye," by means of which electricity may be controlled by light. To demonstrate what the electric eye is and how it works, the "House of Magic" speaker performs a trick which he calls "lighting an electric lamp with a match."

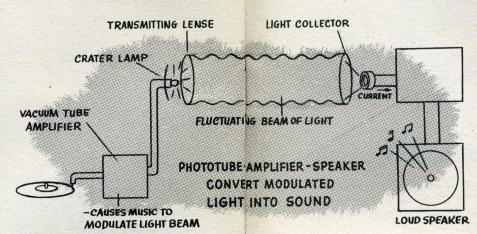
The audience sees a box with an electric lamp on top of it and a phototube mounted on its side. With the stage mostly in darkness, the speaker uncovers the electric eye. The eye is so connected that when no light strikes it, it will not allow any electricity to flow through. The lamp, therefore, is out. But when the speaker holds a lighted match in front of the phototube, the eye "sees" the light, passes current, causes a magnet to pull the circuit shut, and lights the lamp.

Move the match away and the eye stops the current. The lamp goes out again.

In its practical application the phototube is commonplace now. It opens and closes doors, turns on drinking fountains, keeps cloth straight in big mechanical looms, selects the winners in "camera finish" horse races. Through research, the number and variety of its tasks are constantly increasing.



Sound becomes light ..... Light becomes sound





### Hearing Light

The "electric eye" can see things the human eye could never distinguish—minute variations in color, movements too fast for the human eye to follow, wavelengths of light beyond the normal sight range. This versatility enables the "House of Magic" lecturer to demonstrate that we can actually hear light, and can send music on a light beam as readily as we send it along a wire or by means of radio waves.

Again he lights a match. But this time the perceiving electric eye is connected to a radio loudspeaker rather than to an electric lamp. While the match burns, the loudspeaker emits a rumbling sound. And when the match sputters out, the sound likewise dies. As a beam of light from a flashlight is flicked back and forth across the electric eye, a snapping sound results. There is no other way to explain it: we are "hearing" light! As the electric eye sees light, it sends current to the loudspeaker and, as the light changes, the sounds from the loudspeaker change accordingly.

To demonstrate the extreme sensitivity of the electric eye, the lecturer now shows how it can perceive light changes as swift and complex as the tonal variations of music. On one side of the "House of Magic" stage is a phonograph, connected with a tiny "crater" lamp in such a way that the intensity

of the lamp's thin beam varies in unison with the musical vibrations coming from the record being played. The speaker aims this dancing pinpoint of light across the stage. On the other side the beam is picked up by an electric eye, which transforms all the minute variations in the light again into electrical impulses and causes a loudspeaker to broadcast the music.

Let the speaker interrupt the light with his hand, and the music stops—showing conclusively that the music issuing from the loudspeaker is actually being sent over this pulsating beam of light.

Until the war, the principle of transmitting sound over a beam of light was used only for a few spectacular experiments and stunts. When war came, however, its possibilities were quickly investigated. It was apparent, for instance, that if two stations communicated with each other by means of a beam of light, their messages could not be "overheard" by the enemy in the way that radio messages are intercepted. Also, a special infra-red beam could be used day or night to replace the old systems of wigwag signals. The Research Laboratory helped the Navy develop such a system; General Electric built much of the equipment; and today this bit of electrical magic is used extensively for ship-to-ship and ship-to-shore communication.



# counter in use during the Bikini atom-bomb tests.

#### Counting X-rays

It is impossible for the "House of Magic" show to give more than the smallest hint of the Research Laboratory's far-reaching investigations into atomic energy—investigations that have resulted not only in the construction of such massive "atom-smashers" as the Betatron and the Synchrotron, but in the planning of an entire new laboratory.

One of the instruments which the atomic specialist frequently uses, however, is a small and interesting gadget known as the Geiger-Müller counter. In the Laboratory the Geiger-Müller counter is a guard, giving warning of dangerous, invisible radiations. The "House of Magic" speaker demonstrates how it sounds its warning and actually "counts" these radiations.

The heart of the Geiger-Müller counter is a special tube. Inside this tube is a wire surrounded by a very thin metallic cylinder and the tube is filled with argon gas at low pressure. When a speeding atomic radiation strikes the argon, the gas is ionized, that is, some atoms are split into electrons and positive ions. The electrons are negative charges, so when a positive voltage is applied to the wire in the tube, they are drawn to it and produce an "impulse" current from the wire through the circuit outside the tube, which causes the counter to click and a meter to register the number of clicks—thus informing the scientist not only of the presence of the radiations but also of their intensity.

#### Shake hands with your shadow

The bright beam of a spotlight catches the "House of Magic" speaker and pins his shadow darkly against a screen he has erected on the stage. Hopauses there momentarily. Then when he moves from the screen, he walks away from his shadow!

Like the speaker in the picture below, he can turn back to the screen and shake hands with his own silhouette.

As with all the demonstrations of the "House of Magic," the explanation of this detachable shadow lies in scientific fact uncovered through research. Scientists have found that if certain materials are exposed to light, they continue to glow for a while after the light has moved away. These phosphorescent materials coat the screen on which the speaker's shadow falls. The areas of the screen exposed to the spotlight continue to glow when the light is turned off; the shaded areas remain dark; and so, for as long as the glow persists, the screen holds the outline of the shadow.

Again we see how "research of the past has given us new and better things today." For the principle of "light persistence" which makes this "House of Magic" trick possible is the same principle which enables a radar screen to give a clear picture.

CAUGHT on a special screen, the lecturer's shadow refuses to follow him, holds still while he shakes its hand.



# Picture of an explosion

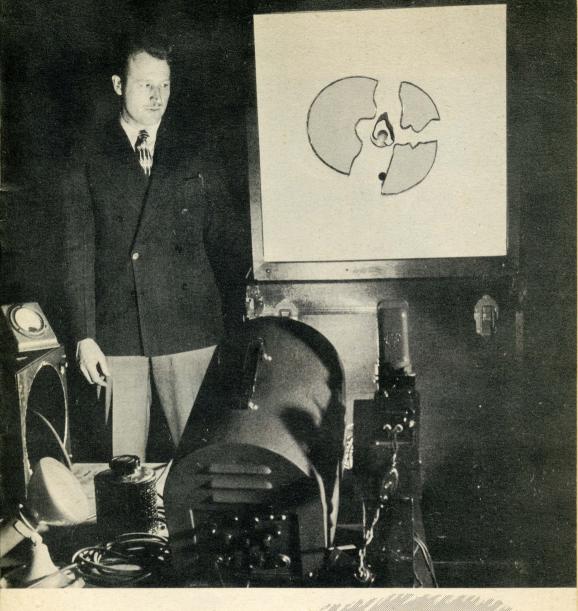
Stroboscopic light can, as has been explained, "stop" the motion of a wheel turning at many thousand revolutions a minute. Suppose we increase the speed of this wheel, faster and faster, beyond the speed of sound, until it flies apart. The motion is still not too fast for the stroboscope lamp teamed with an electric eye. Using an ingenious wiring circuit, we can obtain a picture of the wheel at the very instant it breaks into pieces. On the opposite page, for example, is a stroboscopic picture of a turbine wheel as it shattered at 43,000 revolutions per minute.

In the "House of Magic" show the metal turbine wheel is replaced by a small paper disk. The disk is turned by a high-speed motor. As the motor builds up speed the paper whines a louder and louder protest until with a pop! it explodes and hurls its pieces across the stage. But on the screen behind the disk there is left an image of the paper in the very process of exploding.

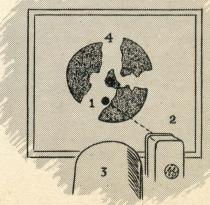
How was this impression left on the screen? By a clever combination of an electric eye, a stroboscope lamp and a "retentive" phosphorescent screen like that which enabled the speaker to shake hands with his shadow. The electric eye is placed in the screen in such a way that the paper disk covers it. When the disk fractures, the electric eye is uncovered and receives light. Very swiftly the eye sends a pulse of energy to the stroboscope lamp, causing it to flash. All this takes so little time that the hurtling bits of paper have been able to move only a small part of the way across the screen. The pulse of light "catches" them in their flight, outlining their shadows on the phosphorescent screen.

When this equipment is put to practical use in the laboratory, as in the test of the turbine wheel, a camera is used in place of the screen. The resulting photographs reveal the pattern and exact position of the break, and so tell the metallurgist where he must strengthen his product to improve performance.





THIS EXPLOSION TOOK ITS OWN PICTURE. When this paper disk flew to pieces, it left an image of the explosion. How? While the disk remained whole, it covered up an electric eye, 1. As the disk flew apart, the eye could "see" a beam from the lamp, 2. This caused the eye to set off a flash from the stroboscope lamp, 3. The shadows of the flying pieces, 4. are recorded in flight by the special screen. In the laboratory, this same principle was used to take the picture of the turbine wheel at the instant it flew apart.





#### Running a motor on Sunlight

All energy, all power on earth, comes from the sun. Sunlight stored in coal and oil, sunlight lifting the water vapor so that it will fall again as rain—these are the ways the sun's power is used by man. But for decades men have dreamed of deriving power directly from the sun.

Scientists of the Research Laboratory have—at least in a small way—made this dream a reality. With special "photo-voltaic" cells made of selenium, platinum and cadmium, they convert the rays of the sun directly into electricity. The "House of Magic" has a bank of these cells connected to a small motor, capable of turning a disk. When a floodlamp (in place of the sun) is shone on the cells, each one generates 16 millionths of a watt of power. The motor begins to turn. As the cells receive more and more light, the disk revolves faster and faster until its painted spokes become an indistinguishable blur.

The sun motor, pointing to an achievement to be realized far in the future, demonstrates the continuing, expanding quality of research. As the "House of Magic" lecturer says in conclusion: "Scientific research of the past, applied today, has given new things for greater health, comfort and convenience. In the same way, scientific research and engineering of today, applied in the future, will give us new and better things for better living tomorrow."

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