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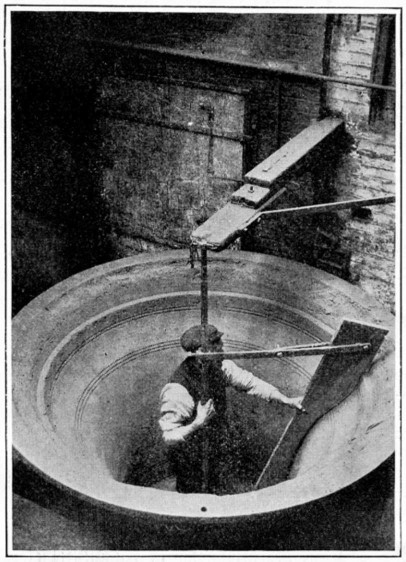
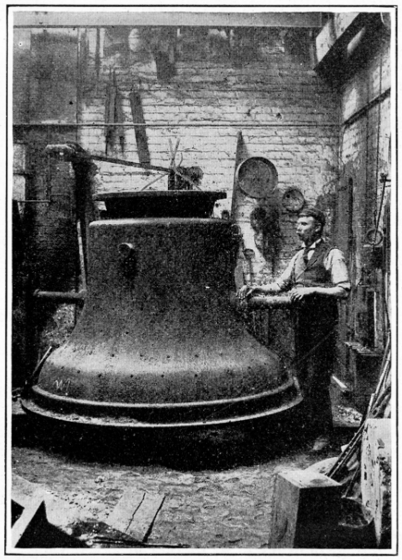
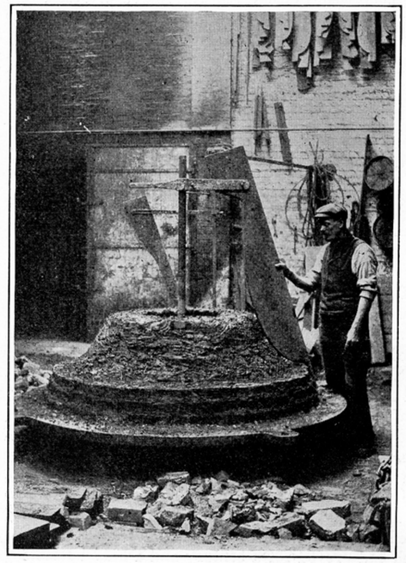


Molding the outer case of the mold. The first step is the building of the mold, the most vital step in the evolution of the bell. A blunder here might mean so dismal a failure that the ordeal of casting would have to be repeated.

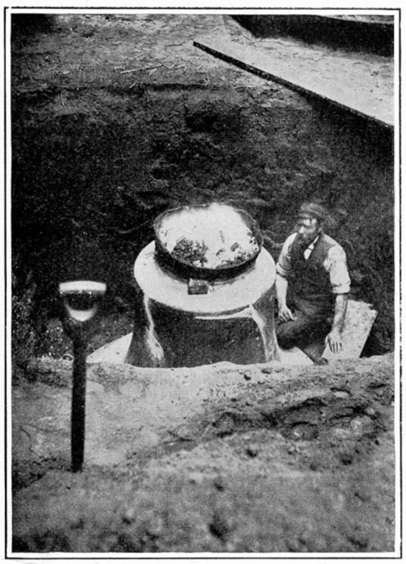


The mold of the bell complete and the outer case fitted over the core. For the purpose of securing uniformity of shape and thickness, the two sections of the mold should precisely correspond with each other.

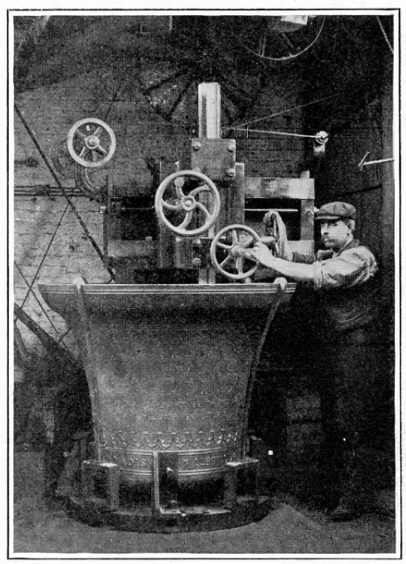


The core is coated with loam, smoothed with a delicately adjusted crook or template, worked on a pivot, and then thoroughly dried. Then an iron hood is used to form the outer side of a future "Great Peter."

The core of the bell complete. This task concludes the difficult operation which forms the shape and the dimensions of the inner side of the structure, and is an important feature of the work.



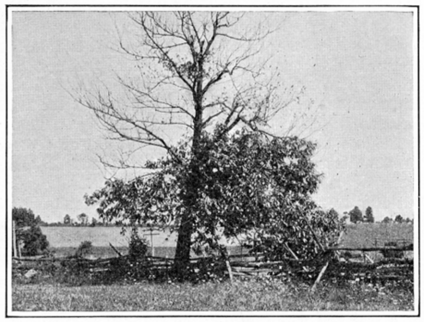
Core in the pit. Drying the mold. At the bottom of this deep pit, under the mouth of the furnace, the workmen brick up a structure called the "core." This work forms the shape and dimensions of the inner side of the bell.



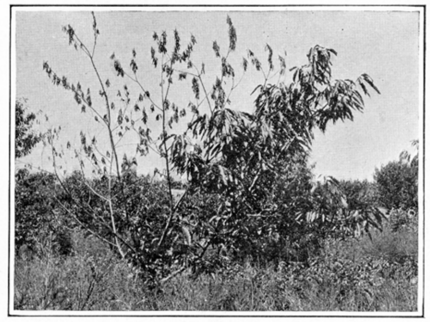
The bell, on being transferred to the tuning shop, is tuned in the machine shown and designed for the purpose. This operation completes the greatest revolution in the bell world, as prior to it the bell was nearly always out of tune.

HOW BELLS ARE MADE.—[See page 238.]

Very early stage of the Blight; infection of twigs on top of tree. Note girdled twig, bearing withered leaves (upper right side).



Chestnut tree partly dead. Note sprouts with leaves near top, dwarfed leaves on middle branch, right side, and healthy lower branches and leaves.



Orchard chestnut nearly dead from Blight: showing characteristic withered leaves, which finally change to a brown tint.

The Chestnut Tree Blight

An Incurable Disease that has Destroyed Millions of Dollars Worth of Trees

Photographs by J. F. Collins and J. F. Brewer. Courtesy of Dr. Haven Metcalf, Divison of Forest Pathology, U. S. Department of Agriculture.

WITHIN recent years the chestnut trees of the eastern part of this country have been attacked by a previously unknown disease which has already destroyed trees to the value of many millions of dollars, and which threatens the early extinction of the chestnut throughout the area affected. The chestnut blight, bark disease or canker, as it is variously termed, was first recognized as a serious disease in Bronx Park, New York city, in 1905, but it appears to have existed on Long Island since 1893. It has now spread into at least ten States and has practically killed all chestnut trees in the counties adjacent to New York city, and infected all in a much larger area, while foci of infection are scattered from northern Massachusetts and central New York to western Pennsylvania and southern Virginia.

The disease appears to be confined to the species of the genus *Castanea*. The American chestnut, the chinquapin, and the cultivated European chestnut are readily subject to it, but the Japanese varieties, which some investigators hold responsible for the introduction of the disease, show much greater resistance.

The bark disease appears sooner or later to exterminate the chestnut trees in any infected locality. Seventeen thousand large trees have been killed in Forest Park, Brooklyn. The financial loss already caused by the disease is estimated at $25,000,000, half of which has been incurred in and about New York city.

The chestnut blight is caused by a parasite fungus named *Diaporthe parasitica*. When the microscopic spores, or reproductive cells, of this fungus enter a wound in the bark they produce a spreading sore which soon girdles the trunk or branch. If the trunk is the part affected the tree is killed, perhaps in one season, but if only small branches are attacked the rest of the tree may survive for several years. Infected limbs with smooth bark soon show dead sunken areas which enlarge and become dotted with yellow or brown fruiting pustules, about as big as a pinhead, which in a moist atmosphere extrude long twisted strings of yellow summer spores. These spores are disseminated by wind, insects, birds, squirrels, etc. The winter spores, which are found in late autumn, are disseminated in the same manner in the following spring.

Trees or branches that have been girdled by the fungus assume a very characteristic appearance. If the girdling is completed late in the season the leaves of the following spring are small and yellowish, while if the girdling is completed in early summer the full grown leaves assume a peculiar red-brown tint, which may be recognized at a long distance.

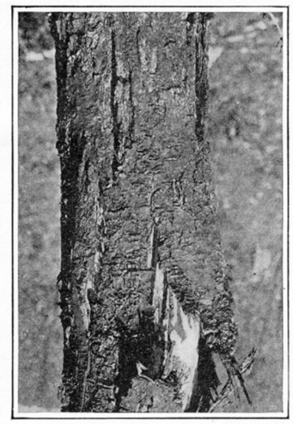
Later, these leaves become darker and wither but do not fall for a long time. The burrs on a branch girdled in spring usually remain hanging during the winter, when they constitute the only conspicuous symptom of the disease. One of the most easily detected and most persistent symptoms is the growth of sprouts or "suckers" below the girdling lesions of trunk and branches, as well as at the base of the tree.

The disease is spread by the spores of the fungus which are washed down from infected twigs to lower parts by rain, which may also carry them through short distances in general. As they are sticky they adhere to dust into which they are thus washed down, and this infected dust is carried to other trees by wind, but the spores, when free from dust, are not apparently disseminated by wind. They appear to be spread extensively by birds, especially woodpeckers, by squirrels and other rodents and by insects. The disease is carried bodily to great distances in tan bark and unbarked timber. One of the most prolific sources of infection has been the transportation of diseased nursery stock.

The spores may develop in any moist hole in the bark. The hole may be a cut or wound, but by far the most common place of infection is a tunnel made by one of the insects known as borers, for these tunnels are moist even in dry weather. The development takes place in the inner bark and cambium layers, and the fruiting pustules are subsequently extended through the outer bark.

No method of producing immunity to the disease in individual trees or of curing them when attacked has yet been discovered. The most effective individual treatment, however, would be of little value in the present situation, for it would not be practicable to apply such treatment to forest trees.

Complete destruction of chestnut trees by Blight. As yet no remedy has been found.

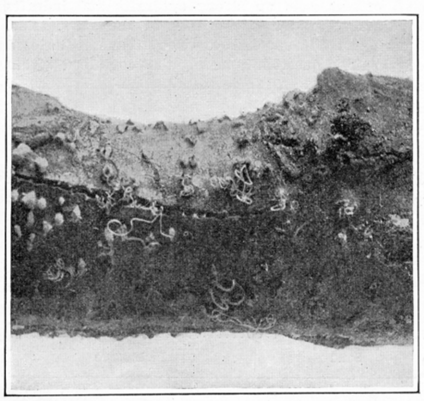


Tree casting shredded bark after death from Blight.

A method of controlling the disease which seems more practical and which has been tested with considerable success is outlined in Bulletin 467 of the U. S. Department of Agriculture. The investigations made by the department soon showed that the disease does not advance rapidly in a solid line but spreads from isolated centers, often many miles in advance of the main line of infection. It seemed probable that these centers of infection, if detected at an early stage, could be eliminated without great expense, thus materially checking the progress of the disease. During the last three years this method has been tested in the territory within about thirty-five miles of Washington. Fourteen points of infection were discovered and the infected trees were destroyed. Up to June, 1911, the disease had not reappeared at any of these points and at that date the experimental area appeared to be free from infection.

If this method could be applied on a large scale with equal thoroughness and success it would probably result ultimately in the control of the chestnut blight, but the carrying out of a comprehensive campaign of this sort is confronted by serious legal and other difficulties. The disease already exists in ten States, and threatens to exterminate the chestnut within its range. The issue, therefore, is a National one, but the Federal Government is not empowered to meet it. Each State must act for itself, and the efforts made to control the disease in any State may be seriously handicapped by

Bark of young chestnut tree, showing canker covered with wart-like pustules, which bear the minute spores of the Blight.



Pustules are here shown producing gelatinous threads, bearing summer spores of the Blight (enlarged).

the negligence of adjacent States. In most of the States, furthermore, it will be necessary to pass special laws and make specific appropriations for the control of the disease, as has already been done in Pennsylvania.

The first thing to be done in each State is to determine the exact range of the disease and, particularly, to locate the advance points of infection. This is the most difficult part of the programme because the work must be directed by experts in plant pathology and carried out by specially trained and trustworthy assistants. The diseased trees in the advance stage of infection must be destroyed or marked and all neighboring chestnut trees carefully inspected. Scouting may profitably be suspended between October and April, when the symptoms of disease are very obscure, but the destruction of marked trees may go on through the winter. The trees should be felled and barked and the bark and brush should be burned over the stumps—or elsewhere, if the stumps are barked down to the ground. The barked timber is not known to carry infection and it may, therefore, be shipped and used. This work of destruction does not require expert pathologists and can be best directed by the State forestry officials.

After all advance spots of infection are eliminated an immune zone must be established along the border of the area of general infection by destroying all chestnut trees, diseased or healthy, within a belt some ten miles wide, across which the disease is not likely to be transmitted. The chestnut trees behind this barrier may be abandoned to the disease but they should be felled and used as soon as possible.

Pennsylvania has set a praiseworthy example by creating a commission empowered to control the chestnut blight by such methods as may seem necessary, to order the destruction of diseased trees, to destroy such trees and assess the cost of destruction on owners who do not promptly obey the order, to destroy healthy trees (with proper compensation to the owner) in order to check the spread of infection and to establish and maintain quarantine on chestnut products and nursery stock. Liberal appropriations are provided and penalties are prescribed for violation of the regulations.

The life of slightly infected ornamental or orchard chestnut trees can be prolonged for several or many years by cutting off small infected branches, gouging out diseased parts of large limbs and trunk and coating the wounds with tar. Spraying with any of the standard fungicides is powerless to check the disease after it has started in the inner bark but it may prevent infection from spores carried to healthy parts by rain or other agencies. Strewing slaked lime about the base of a tree and whitewashing the trunk and large limbs appear to have some effect in preventing infection and the ravages of borers. Trees should be carefully examined several times during the growing season.

In view of the uncertain future of the chestnut the Department of Agriculture advises against planting chestnut trees anywhere east of Ohio and warns western chestnut growers not to purchase stock from eastern nurseries. Owners of chestnut woodland within the area of general infection are advised to convert their trees into timber as quickly as possible, as the still living trees will soon die and rapidly deteriorate.

Outside this area careful inspection, prompt felling of diseased trees and burning the bark and brush over the stumps are advised in the owner's interest, even when not required by law. Owners of ornamental chestnut trees are warned against charlatans, who in many cases have extorted large sums for worse than useless treatment. Reliable tree specialists will have nothing to do with trees affected with the chestnut blight. The department will send copies of its publications relating to the chestnut blight, and typical specimens of diseased tissue (previously soaked in formalin to prevent infection) to all applicants, and will examine suspected specimens sent to it.

In conclusion, the bulletin lays stress on the great importance of protecting the chestnut forests of the South, the source of the best chestnut timber, where the blight has already appeared in a few spots.

A still less hopeful view of the situation is taken by Dr. W. A. Murrill, assistant director of the New York Botanical Garden, who investigated the blight when it appeared in Bronx Park and discovered and named the fungus which causes it. In the March issue of the *Journal of the N. Y. Botanical Garden*, Dr. Murrill criticises the action of the interstate convention recently held at Harrisburg in adopting resolutions in favor of a general campaign similar to that already begun in Pennsylvania. Dr. Murrill thinks that other States would be unwise to duplicate the costly Pennsylvania experiments or to adopt methods which have not been tested and are pretty certain to fail. He believes that the blight cannot be controlled in the forest by the cutting out method because it is practically impossible to locate all advance infections or to eradicate all those that are located and the secondary infections due to their widely disseminated spores. He says, moreover, that for ten to twenty years after the felling of the trees the disease would affect and be spread by sprouts from their roots. Dr. Murrill places little reliance on the published account of the extermination of the blight in the vicinity of Washington, and says that no tree or grove affected by the disease has ever been saved. He asserts, furthermore, that even if all advance infections could be eradicated, all of the foresters connected with the government and the entire army of the United States would be utterly powerless to oppose the progress of the disease in its main line of advance.

"Blowing" and "Sucking" Wells

THE term "blowing well" is applied to a well which, under certain circumstances, gives out a current of air from any small aperture at its summit. This current is often strong enough to lift and blow away light objects placed over the aperture, or dropped into the casing of the well. Its emission is frequently accompanied by a whistling, roaring or moaning noise, which may be audible at a distance of several rods.

As a rule "blowing" wells are also "sucking" wells, i. e., at times the direction of the air current is reversed, the air being drawn into the well. Cases are recorded, however, of wells that always "blow" and of others that always "suck," but these are rare. The term "breathing well" has sometimes been applied to the common type of well that both "blows" and "sucks."

Many years ago the foreign scientific journals described a number of wells at Meyrin, a little commune in the canton of Geneva, Switzerland, which were utilized as barometers by the inhabitants. These wells, which were very deep and were no longer used for drawing water, had been tightly blocked up with masonry except for an orifice of some three centimeters in diameter, through which air currents issued and entered in the manner above described. One of these had been fitted with a whistle, whereby the sound of its blowing was rendered audible at a great distance. The indraft of the air was regarded as a prognostic of fair weather; while strong blowing was believed to be a sure token of an approaching storm.

In recent years the occurrence of blowing wells has been reported at many places in Europe and America. Those in the United States have been studied by the Geological Survey, and their phenomena are now fairly well understood. The Survey has recently published the following statistics of the distribution of such wells.

Although the following list is probably far from complete, we may nevertheless infer from it that, compared with the total number of wells in this country, the number that exhibit the phenomena of blowing and sucking is not large. It is not surprising, therefore, that such wells are looked upon as local marvels, and in some places are among the objects of interest regularly exhibited to tourists.

Inspection of the table also shows that such wells are usually deep, and that they exist in a great variety of materials, having various degrees of porosity.

The names "weather well" and "barometer well" often locally applied to wells that blow and suck reflect the popular belief that the behavior of these wells is governed in some way by the weather; and this belief is in the main correct, i. e., the phenomena, in a majority of cases, depend upon fluctuations in the barometric pressure, and these in turn are broadly related to changes in the weather. One of the first persons to test this hypothesis experimentally was Prof. J. T. Willard, of the Kansas State Agricultural College. Having heard of a well of this character at Winona, Kansas, he visited the spot, sealed the top of the well airtight by means of mortar and plaster of Paris, and inserted a small brass tube connecting the well with a gage. The latter consisted of a U-shaped glass tube, the bend of which for several inches up was filled with water. The fluctuations in the level of the water, read by means of an attached scale, indicated the direction and force of the air movement at the top of the well. By comparison with readings of a mercurial barometer it was shown conclusively that the air in the well exerted a pressure outward when the barometer fell, and yielded to the pressure of the outer air when the barometer rose. The explanation of the ordinary phenomena of sucking and blowing wells is, therefore, that a body of air, inclosed in the earth and communicating with the exterior by only one or a few small orifices, sets up strong outdrafts and indrafts in adjusting its tension to that of the air outside. It must not be supposed, however, that the inclosed body of air in question is merely that contained within the well itself. The volume of the latter would probably be far too small to produce the violent effects observed. As Prof. Willard pointed out many years ago, each of these wells doubtless taps a subterranean reservoir of air, probably filling the interstices of sand or gravel beds. When the pressure of the external air is diminished some of this imprisoned air escapes, and the greater the fall of the barometer the greater the force with which the air is expelled. The fact that the majority of deep wells, closed at the top except for one or more small openings, do not exhibit the phenomena of blowing and sucking is, therefore, explained by the fact that they are not able to draw upon any considerable body of imprisoned air besides that contained in the well.

A serious result of the sucking process is often observed in winter. During the occurrence of high barometric pressure and its usual accompaniment, low temperature, a quantity of cold air is drawn into the well, and the water freezes, even at a depth of 100 feet or more below the surface of the ground.

The foregoing simple explanation of blowing and sucking wells does not apply to all cases. Fluctuations of water-level may doubtless give rise to similar phenomena. Suppose, for example, that a heavy fall of rain causes a general rise of the water-table in a water-bearing stratum of large area lying beneath an impervious stratum, the latter being perforated at only a few points by wells. The air imprisoned above an extensive sheet of water will thus be forced through a few small openings, each of which will be the source of a violent air current.

Fluctuations in the temperature of the outside air may also play a part in these phenomena. It is well known that many caverns, communicating with the outer air by small openings, blow in summer and suck in winter; the air within maintaining a nearly uniform temperature while that without varies with the season. According to Prof. Barbour, many observers notice a diurnal reversal of the air current in wells, corresponding to the diurnal period of the temperature.

Lastly, wells occur in which there is a continuous indraft, or a continuous outdraft. Two examples of the former exist in Georgia, and were described a few years ago by Prof. S. W. McCallie. In these cases, the air currents are entirely independent of atmospheric pressure, and are due to the friction of the air of a rapidly flowing subterranean stream of water. Prof. McCallie compares the action of such a stream to that of Richard's water air blast, found in many laboratories. The well forms the inlet for the air, and the rapid stream in the subterranean channel, into which the well opens, completes the conditions necessary for an ingoing air blast. As the air is constantly being drawn in at this point, it must escape constantly at some other point; if the latter happened to coincide in position with a well, we should have a well blowing constantly, without regard to the barometric pressure.

BLOWING AND BREATHING WELLS.

States.	Number of localities.	Depth feet.	Material.	Age of Material.
Arizona	One	....	....	....
Arkansas	Several	*100	Limestone	Paleozoic
Indiana	One	120	Sandstone	"
Iowa	One	70	Gravel	Pleistocene
Louisiana	"	80	Sand	Tertiary
Michigan	"	....	"	Pleistocene
Minnesota	Many	50–150	Sand and limestone	Pleistocene and Paleozoic
Missouri	"	*170	Limestone	Paleozoic
Nebraska	"	*1,000	Sandstone, gravel and sand	Cretaceous, Tertiary, and Pleistocene
New York	Several	*150	Gravel and sand	Pleistocene
Oregon	One	360	Sand and sandstone	Tertiary
South Carolina	"	120	Sand	Cretaceous
Texas	Several	*300	....	....
Washington	"	*500	Lava beds	Tertiary and Pleistocene
Wisconsin	One	100	Sand	Pleistocene

*Depth of deepest well here listed for the State.

WELLS HAVING CONTINUOUS INDRAFT.

Georgia	Two	100–150	Limestone	Tertiary