METEOROLOGY

Speed of Lightning Revealed By Unique Camera Set-Up

Main Discharge Travels Upward From Ground Following Path Established by Faint Downward Leader Stroke

HOW FAST does a thunderbolt travel? This question has been answered by Dr. B. F. J. Shonland of the Cape Town University, and H. Collins of the Victoria Falls and Transvaal Power Company.

Using a camera provided with two lenses revolving in a circle at opposite ends of a diameter, an arrangement described by C. V. Boys in 1926, the two experimenters photographed a number of lightning strokes between earth and cloud. A moving lens tilts the image of a lightning flash on the plate much as a focal plane shutter causes a swiftly moving automobile to seem to lean forward. The other lens, moving in the opposite direction, tilts the image the other way, so that the real angle of tilt is found as half the angle between the two images. Knowing the speed of the lenses, which made 1500 revolutions per minute, the experimenters could find not only the duration of the discharge, but which way it was going and how fast. They could determine also how long the luminosity persisted after the discharge had ceased, and other details.

Almost always, they found, the main flash was preceded by a faint "leader," as they call it. This traveled downward from the negatively charged cloud to the positively charged earth. As soon as it struck the earth, the main flash started upward from the same spot, and followed exactly the same path that the leader had taken, to the cloud.

The leaders were invariably thin, of uniform width, and unbranched. Their speeds ranged from 810 to 19,900 miles per second. They averaged 5,150 miles. The length of the strokes observed varied from 1.6 to 4.7 miles. The longest time occupied by a leader stroke was 1670 micro-seconds for a 4.7 mile stroke. The quickest flash took 69 micro-seconds to travel 3.5 miles. A micro-second is one millionth of a second.

The lengths of the strokes were measured along the crinkly paths registered on the plates. These did not show, of course, the motion toward or away from the camera, and the experimenters estimated that the real lengths of the strokes in space, and consequently the real velocities, were about 30 per cent. higher than those measured.

The leader appeared to be composed of an elongated dart. From the width of the track on the plate, the investigators were able to determine the duration of the luminosity at any point, and assuming that this was the time required for the dart to pass the point, they were able to measure the lengths of the darts. These varied from 80 to 370 feet, the average being 180 feet.

In conformity with the theory proposed by Dr. N. Ernest Dorsey in 1926, the authors believe that the leader consists of an "electron avalanch," which goes ahead and ionizes the air, thus preparing a conducting path for the main discharge that follows.

The main discharge is entirely different in character. It is thicker and brighter, and the thickness diminishes upward. It is more like a soaring flame than a moving dart. Also it travels faster. The speeds ranged from 14,900 to 68,400 miles per second, the average being 28,500 or about 15 per cent. of the speed of light.

Often the main upward discharges were branched—but they branched downwards. After each branch the main stem thinned but did not pause in its upward motion. The branch occurred at or after the moment the head of the discharge passed the point. The branches did not always occur in regular sequence, a lower branch sometimes sprouting out after an upper branch had developed.

The time required for the discharge to reach the cloud varied from 44 to 65 micro-seconds. To reach the end of the last branch took from 40 to 145 micro-seconds. The bright luminosity at the base lasted from 12 to 164 micro-seconds. Usually it was out before the discharge reached the cloud, occasionally not. A faint luminosity, however, lasted much longer, sometimes as much as a fiftieth of a second, as though the path had been heated and continued to glow.

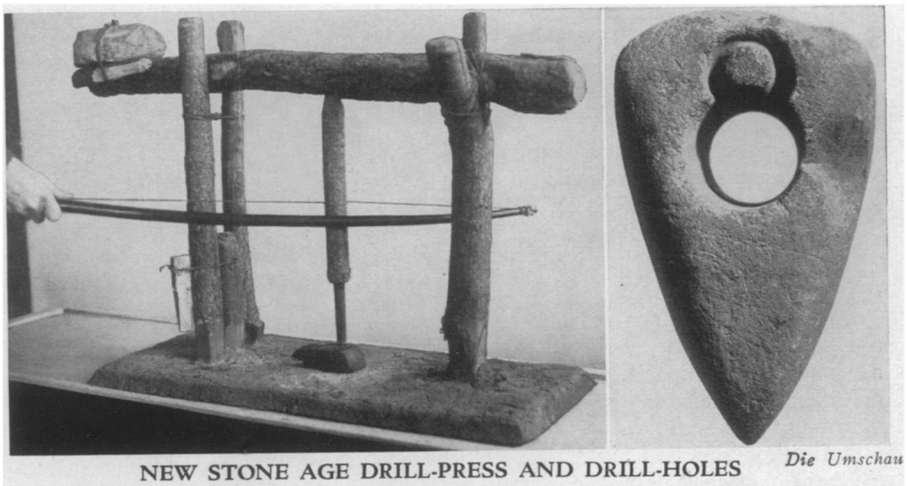
The experiments were made for the Lightning Investigation Committee of the South African Institute of Electrical Engineers, and are to be continued.

Science News Letter, March 17, 1934

ARCHAEOLOGY

Man a Machinist For 10,000 Years

BENJAMIN Franklin is credited with having originated the definition of man as a tool-making animal. But even the immortal Benjamin and all the eighteenth-century natural philosophers who were his peers might well have been astonished at the prehistoric extension which has been given to man's activities not merely at making tools but at making machinery for the mak-



NEW STONE AGE DRILL-PRESS AND DRILL-HOLES *Die Umschau*

The drill-press was reconstructed by Prof. Wolfgang La Baume, of Danzig; the ax-head is an actual Neolithic specimen, with a badly-placed hole that was discontinued before it was completed, and a correctly-placed hole that was bored clean through. The core projecting in the first hole shows that a hollow tool—presumably a bone—was used.

ing of tools. Prof. Wolfgang La Baume, of the Danzig Museum of Natural History and Prehistory, after a careful study of pierced stone axes, hammers, hoes and other tools of the New Stone Age, has built of wood, sinew and other primitive materials a drill press that duplicates their technique quite exactly.

The apparatus is crude but efficient. A Y-forked tree limb driven into the ground supports a stout wooden cross beam weighted at its other end with a stone and free to move up and down between a pair of straight sticks that act as guides. In the middle of the cross beam a shallow hole or socket acts as a bearing for a smaller vertical stick, at the lower end of which is fitted a piece of bone or hardwood that serves as the drill itself. This vertical stick is free to twirl in its socket, and is set in motion by a bowstring, after the manner of the "fire-drill" familiar to all Boy Scouts. The drill is armed with an angular bit of flint, which can eat its way through a piece of bone, wood, or other material with surprising ease, says Prof. La Baume.

For making holes in stone, a procedure surprisingly reminiscent of the most modern metallurgy is used. Modern workers in very hard metals, that defy steel drills, can bore and cut them by using abrasives such as diamond dust, emery and carborundum, on the face of a tool of softer material. So also did the Neolithic machinists, when they wanted to make a hole in a flint ax-head. They used a blunt-ended wooden drill, or the shaft of a deer leg-bone, to twist and twirl on top of a little wet sand.

Prof. La Baume, using this method on his reconstructed Neolithic drill-press, can bore clean holes through very hard stones in very short time and with surprisingly little wear on the bone or wooden tool. The solid wooden rod gives him a clear bore-hole, the hollow bone makes an annular cut and takes out a core. New Stone Age tools, discarded before completion because something went amiss, show both types of boring.

The Danzig archaeologist has also reconstructed a stone-cutting tool employing the same principle to slice straight grooves into flat pieces of hard rock, making "blanks" similar to those from which Neolithic men began shaping their polished stone implements.

Apparently the skilled artificers of medieval Nüremberg, and the craftsmen of the mighty modern works of Essen, can point back to at least ten thousand years of ancestor-machinists.

Science News Letter, March 17, 1934

ASTRONOMY

Nebulae Emptier Than Air; Metals Are Frigid Vapor

THE SPACE between the nebulae is a million times bigger than the space occupied by the nebulae. Yet one might say space is crowded with nebulae compared with the sparseness with which the stars are contained in the nebulae.

This is one of the astronomical facts recently presented by Dr. J. A. Anderson of the Mt. Wilson Observatory in a popular discussion held under the auspices of the Astronomical Society of the Pacific.

The average distance between stars in a nebula like our own galaxy, the milky way, is millions of times bigger than the diameters of the stars. This means that the nebula is a thousand billion billion times as big as the sum of all the stars in it. And there may be some hundreds of billions of stars in one nebula.

Thus a nebula is emptier than ordinary air. If the molecules in a thimbleful of air were strung together side by side the string would go thirty times around the earth. If a similar string of stars were made it would extend only one-seventh across the nebula.

Between the stars there are gas molecules thinly dispersed. Even metals at the low temperatures of interstellar space exist as vapor because the molecules do not meet each other often enough to form solid matter at once. There is also a large amount of dust, as indicated by great clouds which hide all stars behind them. Dust is a hundred million times as opaque as gas.

So much starlight has been emitted since the beginning of the universe that its mass would be equivalent to a hundred galaxies. And there may be a hundred times as much in the form of cosmic radiation.

Science News Letter, March 17, 1934

AERONAUTICS-METEOROLOGY

Lightning Not Dangerous To Aircraft in Flight

LIGHTNING is not dangerous to aircraft in flight.

This is the conclusion of a group of authorities on meteorological and electrical conditions who, as subcommittee of the National Advisory Committee for Aeronautics, reported results of a thorough investigation made since the wreck of the airship *Akron.*

An airship inflated with inflammable hydrogen is no more liable to damage from lightning than one inflated with non-inflammable helium, provided it is properly "caged" with electrically conducting metal framework, the scientists found. Their report states that in the airship the protection is greater the closer the meshes of the metallic framework, the wire bracing, and the wire netting enclosing the gas bags, and particularly the more highly electrically conducting the surface of the outer envelope.

A number of reports of damage by lightning to airplanes were reviewed. It was generally agreed that, "It is possible, without serious complication, to render an airplane practically immune to serious danger either to the airplane or to the occupants."

Though neither airplanes nor airships are in serious danger from lightning, both must make every effort to avoid thunderstorms, the scientists cautioned. The extremely violent and turbulent winds of thunderstorms, rather than the lightning, are the cause of destruction, it was pointed out.

This study of "Hazards to Aircraft Due to Electrical Phenomena" was made at the request of the Navy Department. Members of the subcommittee, appointed by Dr. Joseph S. Ames, president of Johns Hopkins University and chairman of the National Advisory Committee, were: Dr. Charles F. Marvin, Weather Bureau, chairman; Dr. L. J. Briggs, Bureau of Standards; Commander Garland Fulton (C.C.), U.S.N.; Dr. W. J. Humphreys, Weather Bureau; Dr. J. C. Hunsaker, Massachusetts Institute of Technology; Dr. F. B. Silsbee, Bureau of Standards; Prof. John B. Whitehead, Johns Hopkins University; Dr. G. W. Lewis, National Advisory Committee for Aeronautics (ex officio). They were assisted by Dr. M. F. Peters of the Bureau of Standards.

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