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SCIENTIFIC AMERICAN

April · 1936

Vol. 154
No. 4

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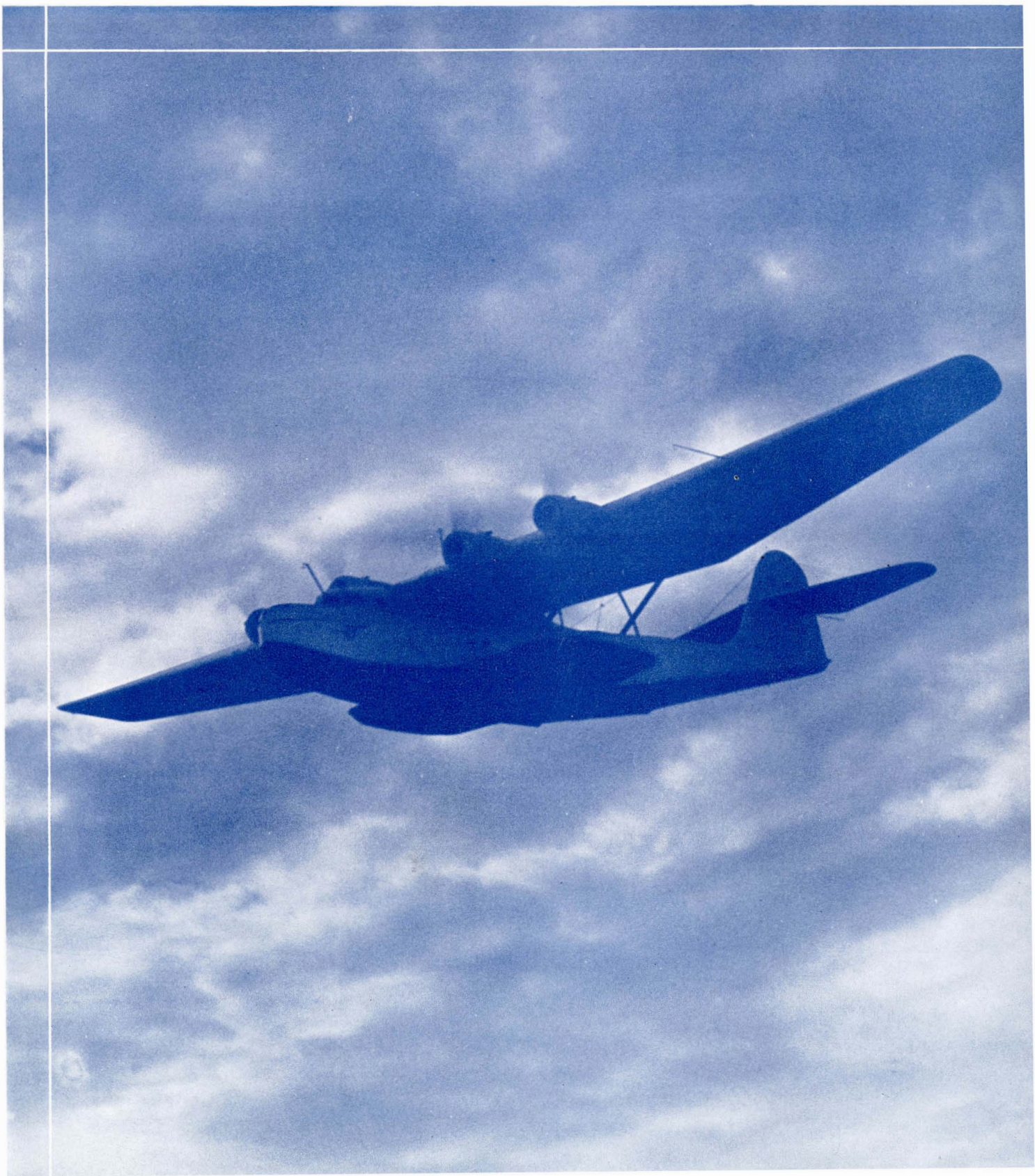

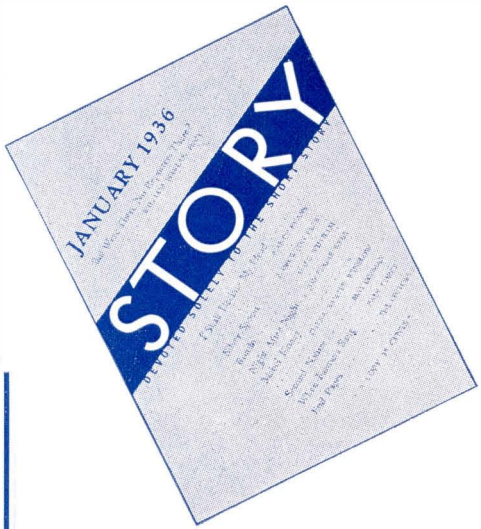

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NINETY-SECOND YEAR • ORSON D. MUNN, Editor

The SCIENTIFIC AMERICAN DIGEST

CONTENTS · APRIL · 1936

COVER

SYMBOLICAL of the progress that has been made in air transport operations during the past few years is the striking photograph by Richard B. Hoit, reproduced on our cover this month. Ships of the China Clipper type have been making history over the Pacific, and as pointed out by Mr. Cleveland in his article starting on page 173 of this issue, we may look forward to the probability that aviation history will repeat itself in the Atlantic sector during the present year.

SCIENTIFIC AMERICAN, April, 1936. Vol. No. 154. No. 4, entered at the New York, N. Y. Post Office as second class matter June 28, 1879, under the act of March 3rd, 1879; additional entry at Greenwich, Conn. Published monthly by Munn & Company, Inc., 24 West 40th Street, New York City.

Subscription price $4.00 per year. Canada $4.50. Foreign $5.00. Manuscripts are submitted at the author's risk and cannot be returned unless accompanied by postage.

50 YEARS AGO IN . . .

SCIENTIFIC AMERICAN

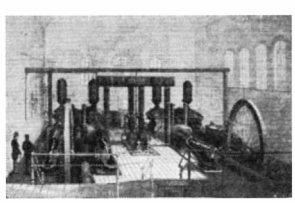
(Condensed From Issues of April, 1886)

BACILLUS—"Dr. Cantani, of Naples, having in mind the fact that the bacillus of consumption is destroyed when other bacteria are grown in the same soil, has proposed to eradicate consumption by introducing into the system other bacilli which are injurious only to the germs of the disease. If an organ of the body be attacked by a bacillus dangerous to human life, he would introduce another, harmless to man but fatal to the destructive bacillus."

INDIAN MARKET—"A gentleman residing in Calcutta having seen our illustration and description of a separator for wheat in Scientific American, writes to this office a long and very interesting letter, giving important statistics relative to the growth and exporting of wheat from India, and suggests that it is a good market for meritorious inventions in the agricultural line, and especially the class pertaining to the cultivation and cleaning of wheat."

MILLS—"The cotton manufacture in 1885 shows the total number of mills in the United States as 826, containing 261,228 looms and 12,280,342 spindles, manufacturing 786,000,000 yards of print cloths per annum. Of these, New England has 481 mills, containing 205,011 looms and 9,481,272 spindles, manufacturing 646,000,000 yards of print cloth."

WATER WORKS—"The method of obtaining an additional supply of water for the city of Brooklyn, N. Y., by means of driven wells, has attracted widespread attention because of the originality and boldness of the plans and the perfect success attained. The pumping engines are provided with automatic cut-off valve gear of the most approved type, using steam pressure of 90 pounds per square inch. The steam cylinders are arranged on the cross-compound plan—that is to say, in each engine, the high pressure cylinder works one water pump and the low pressure cylinder works the other."

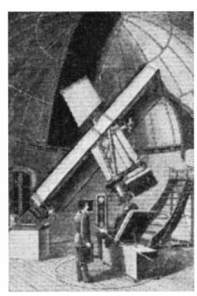


TIN—"A 9000-pound mass of tin ore was recently exhibited at a smelting works in New York. It was taken out of a 29-foot vein in the now well-known Etta tin mine, in the Black Hills."

BAGASSE—"The utilization in sugar making countries of the residual canes—bagasse—for fuel and gas making is an important practical problem which has yet been only partially solved. It is stated, however, in the *Revue Industrielle*, that M. Pellet has succeeded in devising a system of dealing with the material which produces, by direct compression, a combustible containing not more than 40 to 50 percent of water. In this state the waste can be burnt directly in boiler furnaces or carbonized without previous drying."

LIGHTHOUSES—"At the Society of Arts, on March 10, a lecture was delivered by Mr. E. Price Edwards 'On the Lighthouse Illumination Experiments at South Foreland.' The general results of these experiments were that while electric arc light was more absorbed in proportion than gas or oil light as it passed through fog, still its greater intensity enabled it to penetrate much farther than these. The Berlin core carbons of Messrs. Siemens were found to operate best, the core being of graphite."

SPRINKLERS—"It is about ten years since the first automatic sprinklers were introduced into factory buildings, and mainly, we imagine, through the earnest advocacy of the mutual insurance officials, they soon came into general use in such structures."



ASTRONOMICAL PHOTOGRAPHY—"As a few experiments in celestial photography tried last year by means of quite rudimentary instruments gave good results, the Director of the [Paris] Observatory has been pleased to authorize the construction of a special apparatus, which we illustrate herewith. This new instrument consists of two juxtaposed telescopes enclosed in an oblong rectangular metallic case, and separated through their entire length by a thin partition. One of the objectives, of 9½ inches aperture and 12¾ feet focal length, is designed for visual observation and serves as a finder. The other, of 11.4 inches aperture and 11¼ feet focus, is achromatized for chemical rays, and serves for photographing."

SACCHARIN—"Mr. Ivan Levinstein, the President of the Manchester Section of the Society of Chemical Industry, calls attention to a new substance which is extracted from coal tar, and possesses sweetening properties far stronger than the best cane or beet root sugar."

LIQUID CO_2—"A patent recently taken out proposes to produce carbon dioxide gas for liquefaction by having a solution of sodium bisulphate in a leaden container, and running into it some carbonate or bicarbonate, dissolved or suspended in water, the evolved carbon dioxide being drawn off over a drying mixture into a gasometer, from which it is drawn for liquefaction by compression."

OIL—"The report that an artesian flow of petroleum had been discovered in the southern part of Santa Fe County, New Mexico, between the mining villages of Golden and Wallace, has been confirmed, and samples taken to the capital and tested. The oil flows through tubing 55 feet down, and the flow is reported to be copious and steady. The crude oil burns freely and with a good flame. Several claims have already been located in the neighborhood of the well."

STATUE OF LIBERTY—"The pedestal for Bartholdi's great statue has now been completed. The last piece of stone has been put in place, and the last of the large iron girders to which the statue will be fastened is ready for duty. When completed, the statue will look even grander at night than in the daytime, as its electric illumination will give the figure greater prominence. It is proposed to place four large lights at the base of the statue, one at each corner . . . and a powerful shaft light on the torch."

AND NOW FOR THE FUTURE

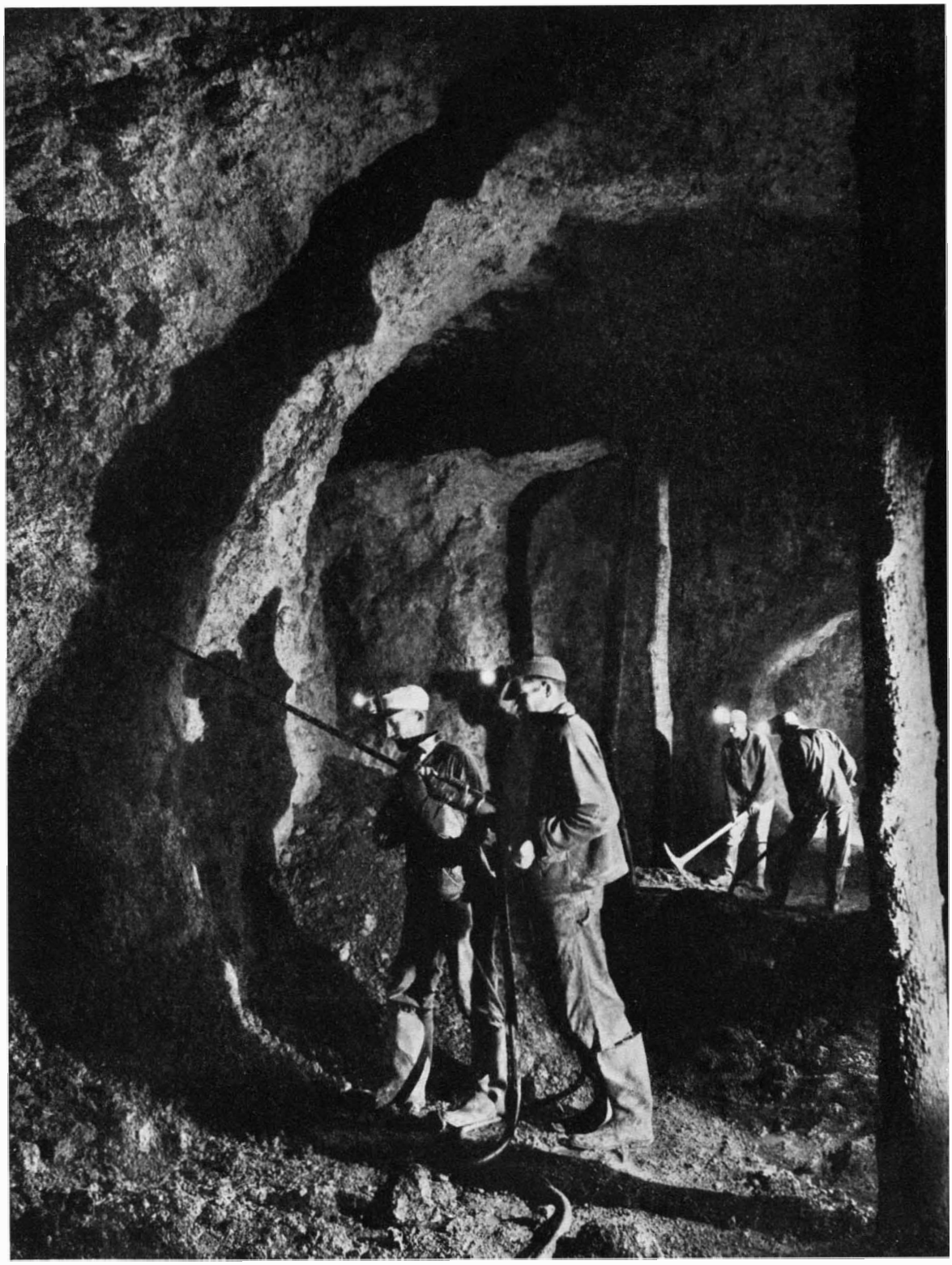
¶ The Mystery of the Neutrino, by Jean Harrington

¶ What is Personality?

¶ Hatchery Trout as Active as Those in a Natural Environment

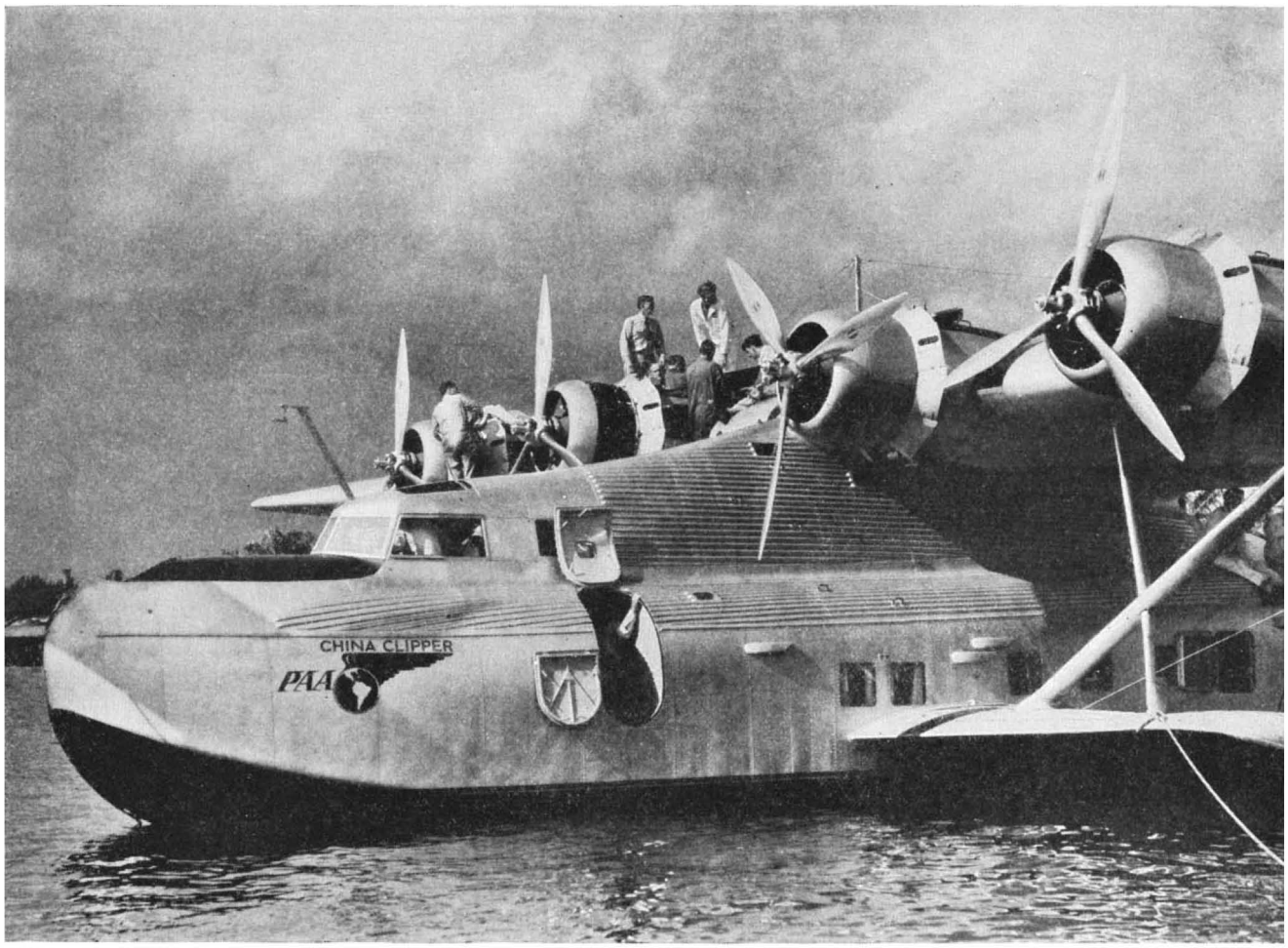
¶ Color Blindness and Strange Sensations

¶ Broadening the Port Facilities of Bordeaux, France, by R. G. Skerrett



WAY DOWN UNDER IN A BAUXITE MINE

THINK of bauxite and you think of aluminum, the light metal that, in 50 years, has won such a definite place in our industrial world. But only about three quarters of all the bauxite mined goes into the manufacture of this useful metal. Large quantities are used by the abrasive and refractory industries; in making quick-hardening cement; in manufacturing aluminum chloride used in petroleum refining; and for making aluminum sulfate, which is largely used in paper making and in water purification. Bauxite is a widely distributed ore, being found in most countries of the world.



Photograph by Richard H. Hoit

China Clipper, **forerunner of giant planes that will soon span the Atlantic**

AND NOW, THE ATLANTIC

One of the Last Areas to be Conquered By Commercial Air Transport . . . Technical Advances Have Outrun Political and Industrial Plans

By REGINALD M. CLEVELAND

NEW YORK to London in 36 hours, with passengers, mail, and express! A decade ago this might well have been the title for a book by a contemporary Jules Verne. Today it is an imminent reality. The North Atlantic, scene of a score of heroic pioneer flights following that first solo blazing of its trail by Colonel Charles A. Lindbergh in May, 1927, which may be said to have touched off the fuse of air transport development the world over, is to become, almost certainly this year, the field of scheduled operation.

This area of uncertain skies and an often troubled sea, one of the last to remain free from the shadow of commercial wings, could be flown today with American equipment, produced in American factories and operated by American airline companies. It presents a contradiction to the other major fields of air transport development in that technical advancement here has outrun political and industrial planning.

In the case of the great international system of air lines grouped under the aegis of Pan American Airways, which circle the Caribbean and run almost the whole perimeter of South America and which extend over Alaska and form a growing network in China, the plan came first; the equipment was developed to suit the exigencies of the plan. The same holds true of the longer tentacles of the European airlines; of Imperial Airways' Empire routes, running down the spine of Africa to Capetown and stretching, first to Karachi, then to Singapore and finally across the Timor Sea to Australia; of the East Indian route of the Royal Dutch Airlines, K.L.M., linking Amsterdam with Batavia and Surabaya; of the French line, spun out by Air France to Indo-China.

Across the South Atlantic, again, the services of Air France and of Lufthansa have followed the development of a commercial demand. And in the most recent and, in many ways the most spectacular, of the extensions of the air-transport web, the 8900-mile line of Pan American joining California with China across the Pacific, the establishment of an airway and the development of air-borne vehicles to fly it, have followed upon carefully considered political and economic

Photographs by Clyde H. Sunderland

Two views of *China Clipper*, flying boat that has made aviation history in the transpacific air service, and from which valuable lessons have been learned

groundwork, carried to a logical end.

In the case of the North Atlantic, however, the picture has been reversed; the anomaly is presented of the perfection of flying equipment fully equal to the task while perhaps the most important transoceanic route of all remains unflown as international agreements are perfected.

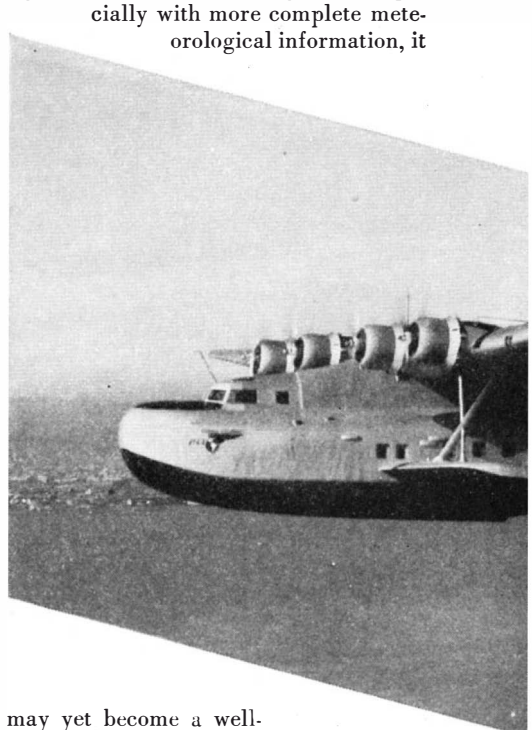
WITHIN recent months, however, these agreements have advanced from a stage of friendly discussion to one of assured commitment. The United States Post Office Department has announced that transatlantic mails will be flown; the State Department has made it plain that it will co-operate with other nations in what, due to the nature of the terrain and bases, must be an international undertaking. Beyond this, representatives of the British Government, the Canadian Government, and the Government of the Irish Free State, have met with our own Interdepartmental Committee for Civil Aviation, and with representatives of Pan American Airways, which does and must hold a key position in the undertaking, to reach definite conclusions.

These conclusions are that the North Atlantic will be flown with mail—and passenger traffic must inevitably shortly follow—on optional routes depending on weather conditions, both seasonal and temporary, which roughly lay down an irregular quadrilateral course across the ocean. The southern and longer route extends from the United States either at New York or a point south of Washington—a matter which has not yet been fully determined—by way of Bermuda and the Azores. The northern extends from the same American base to Newfoundland and thence by a great-circle route to Ireland. The longest over-water hop in either route does not exceed 2000 miles.

Already in the Pacific, the great Clipper ships of Pan American, first the Sikorsky *S-42* as a test plane, and more recently the Martin flying boats, *China Clipper*, *Philippine Clipper*, and *Hawaiian Clipper*, have demonstrated beyond peradventure that they can negotiate a longer stretch—the 2410 miles run from Alameda to Honolulu—with an ample margin of fuel for safety. The Pacific is proving a laboratory for the Atlantic, just as the Caribbean has been for half a dozen years a laboratory for the Pacific operation. There planes have been tested, radio aids have been developed, and men have been trained in preparation for the complex and exacting business of transocean flying.

ANOTHER laboratory is being used with an eye to the Atlantic, and this is the Territory of Alaska. There, although it is overland operation, many of the problems are encountered which must be solved on the third North Atlantic route, which has long been discussed, but for the present is being held in abeyance. This is the so-called northern island route running from Newfoundland or Nova Scotia to Labrador, Greenland, Iceland, and the Faroes. It is a route of short hops, with over water stretches which, as far as range is concerned, are mere child's play as compared with the wide reaches of the Pacific. But it is a route of fog, of ice, of changing conditions of terrain, from the comparatively simple Newfoundland area to the Greenland ice-cap, and, especially, it is a route long stretches of which often lie in the most unfavorable temperature zone, that in which wings and propellers ice up through the combination of dampness with the right degree of cold.

All these conditions are also found on the Alaskan mainland and there Pan American is constantly testing planes, men, and engines with a view to throwing new light on the operation of the route to Asia which Colonel and Mrs. Lindbergh surveyed for it three years ago. With better knowledge, and especially with more complete meteorological information, it may yet become a well-traveled airway to the Old World.



Could one of the 25-ton *Clippers* of the Pacific service be diverted tomorrow to the Atlantic, there is no question that it could make the run, either by way of Newfoundland and Ireland or by way of Bermuda and the Azores, cruising steadily at 150 miles an hour with 16 passengers, a crew of seven, and a ton of mail or cargo, and thus link the Old World and the New on a schedule well within the limit indicated at the opening of this article. But there is something else to consider besides the question of technical efficiency.

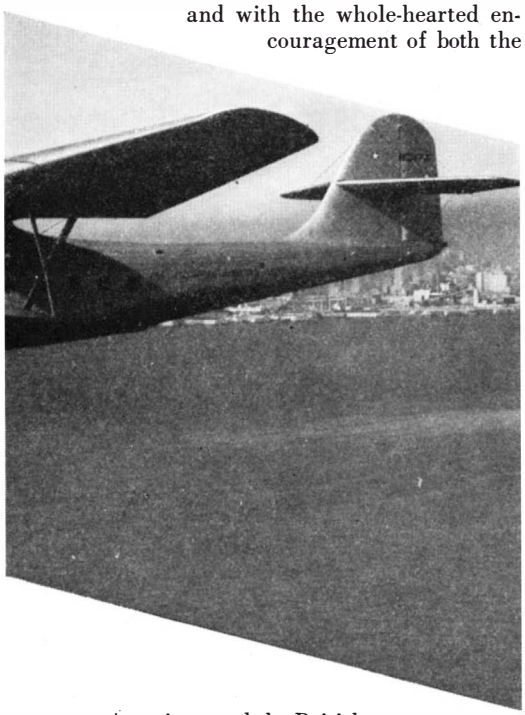
Great Britain and her Dominions beyond the seas control the ports which are needed as bases for any successful transatlantic service in the present state of the art. When the sub-stratosphere plane has arrived, flying at perhaps 20,000 to 25,000 feet with sealed cabins supplied with oxygen and cruising, in the thinner airs, at 250 or more miles an hour, intermediate bases will lose their importance.

Such planes are coming, perhaps sooner than is generally expected. Lead-

ing designers of large aircraft, including Igor I. Sikorsky and Glenn L. Martin, have both predicted flying boats much larger than the current giants of the Pacific within a relatively short time. Both have plans prepared for ships of twice the capacity of the largest present *Clippers*. Mr. Sikorsky especially leans towards the advantages of high-altitude operation.

But for the present—and the Atlantic is to be conquered in the year 1936—bases are important to any scheduled operation which must be predicated on the ability, not merely to get across, but to get across with a payload which will offer some inducement for a venture of so pioneering a character. The far-seeing gentlemen who are at the helms of Pan American and Imperial Airways have long understood this situation, and have been in full agreement upon it.

Now, with the participation of Canadian and Irish Free State authorities, and with the whole-hearted encouragement of both the



American and the British postal authorities, these understandings have developed into overt agreements. And Pan American, with the equipment and the experience, and Imperial, with the bases and with what may be expected to be very comfortable and reliable equipment building for completion late this year, will operate the North Atlantic service together.

They will not be alone, however, from all present indications. The French, the Germans and the Dutch all have their eye upon an Atlantic service. Air France has developed and flown a very large and apparently quite efficient airplane, the Latécoere flying boat, *Lieutenant De Vaiseau Paris*. This six-engined giant, with upper and lower decks and a gross weight of 70,000 pounds, has already crossed the South Atlantic on its line's route between Africa and Brazil, flown up the South American coast to the French colony in Martinique, and thence over a stretch of nearly 2000 miles to Pensacola, Florida. That it turned turtle while at anchor in the harbor in a sudden tropical storm was really no fault of the airplane. The ship, while not fast in the sense of the American *Clippers*, can carry a heavy load for a long range, and the French have other big boats building.

By the time this is in print, French and German missions will have visited Washington to discuss the Atlantic problem. It is already clear from the position taken by the State Department that they will be met in a co-operative spirit.

THE Lufthansa, which already operates an extraordinarily successful and expeditious mail service across the South Atlantic, using Dornier Wal flying boats which it catapults from mother ships at Bathurst and Natal, has already conferred both with Washington and with Pan American executives in the person of its managing director, Mr. Martin Wronsky. It is his opinion that there is enough mail business by air in the North Atlantic for all comers, and he said unequivocally while here that his company would at least conduct experimental flights of the type which are being operated in the South Atlantic.

He is not a believer in very large flying boats for passenger service, however. His company has an interest in the Luftschiffbau Zeppelin. He holds that giant airships, such as the *LZ-129*, which will make its first transocean flights this spring, offer the solution for passenger air travel between the United States and Europe. It seems safe to predict that this huge ship, with cabins for 50 passengers, promenade decks, and all the comforts of home, having a cruising speed of 78 miles an hour and a range of more than 8000 miles, will make some round trips over the North Atlantic before its heavier-than-air competitors get under way.

There are not a few experts who agree with Herr Wronsky that the machine-like operation of the veteran *Graf Zeppelin*, shuttling back and forth between Friedrichshafen and Pernambuco, with all the regularity of a limited train, has given good grounds to believe that the airship, properly constructed and manned, is a highly satisfactory solution for transocean travel. They point, too, to the great lift, range, and roominess of this type of vessel, especially in such sizes as the new German ship, to support their theses.

BUT in the air, at least, the race is nearly always to the swift. The magnificent performance of America's aerial *Clipper* ships, reënacting in the Pacific the pulse-quickening drama played a century ago by the merchantmen Clippers in the China trade, leaves little room for doubt that whether giant airships also link the United States and Europe, great wings, supporting the clean hulls of flying boats, will likewise ply the North Atlantic air lanes and bring New York and London little more than a day apart.

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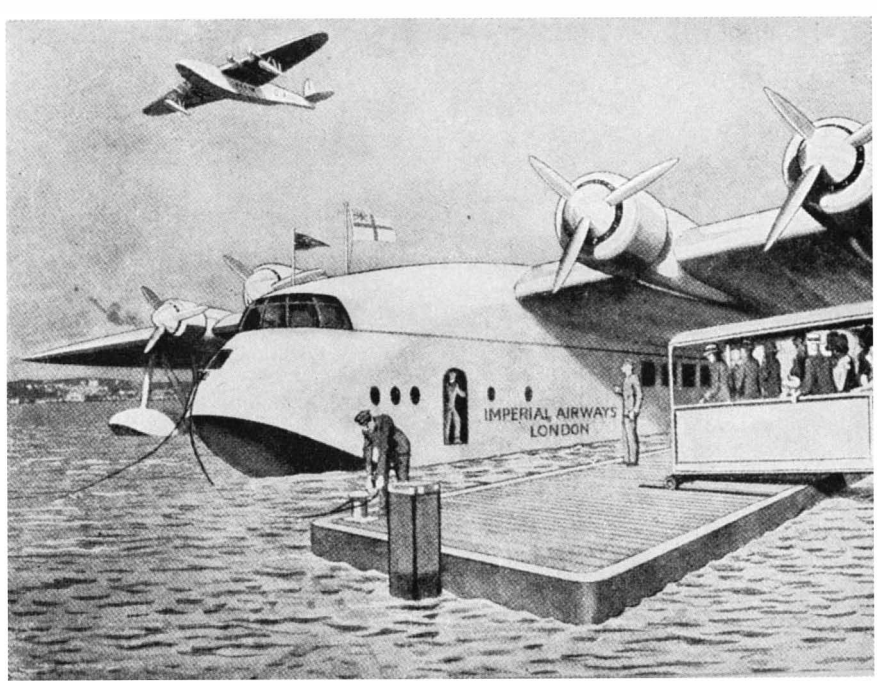
Additional data pertaining to the foregoing article will be found in the following issues of Scientific American: Atlantic flight, February 1934; The Clippers, July 1934, December 1934, and March 1935; LZ-129, *June 1934 and June 1935.*—The Editor.



An artist's drawing of a British flying boat now under construction, for possible transatlantic use, by Short Brothers (Rochester and Bedford) Ltd.

BRIDGE BUILDER
LAWYER
MANUFACTURER
} ASTRONOMERS

"THEY are amateurs who have done some fine work in developing precision telescope drives, and making motion pictures of heavenly bodies, that make professionals green with envy." This is how one professional tele-

The triumvirate which is responsible for the McMath-Hulbert Observatory of Michigan University. *Left to right:* Francis C. McMath, builder of bridges, Judge Henry S. Hulbert, lawyer and banker, Robert R. McMath, maker of stampings

scope designer recently spoke of the amateur-professional astronomical work of three citizens of Detroit, whose photograph and whose observatory and newly constructed solar tower are shown on this page.

Not only have these three amateurs, by sheer merit, crossed over into practically professional astronomical status and been accepted as such, but so has their observatory, which is now a part of the University of Michigan. The three who staff the McMath-Hulbert Observatory are Francis C. McMath, a retired bridge builder, whose biggest single piece of work was the Quebec Bridge, Henry S. Hulbert, a former Senior Judge of Probate in Detroit, now vice-president in charge of trusts in the National Bank of Detroit, and Robert R. McMath, a former World War major in the Aviation Section of the Signal Corps who is now president of the Motors Metal Manufacturing Company, makers of heavy motor stampings. Robert R. McMath has done most of the work on the observatory, and is its director. Prof. Heber D. Curtis, head of the Department of Astronomy at the University of Michigan, himself a fine mechanic, states that Mr. McMath is rapidly becoming a professional astronomer and is a mechanical genius. The McMath-Hulbert Observatory is at Lake Angelus, Pontiac, 50 miles north of Ann Arbor, Michigan.

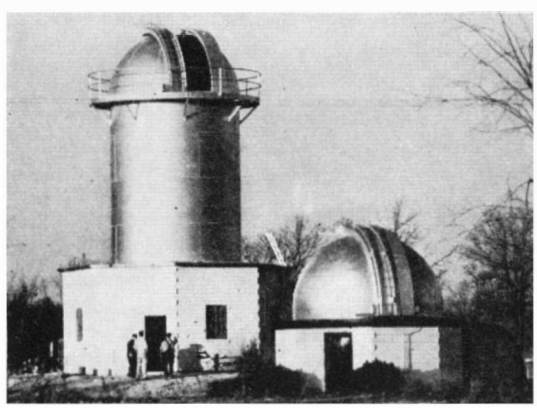
In the photograph two observatory domes are seen. The low one on the right was built several years ago and houses a 10½-inch reflecting telescope with which four notable motion picture reels were taken (of these many hundreds of copies have been sold, at no profit to the observatory). These showed respectively the occultation of the moon, the eclipse of August, 1932, star fields and the motions of Jupiter's satellites, and the famous "solar bomb" of June 19, 1934.

THE last of these motion pictures were taken with an instrument about five feet long, having a name somewhat longer, attached to the telescope. This is the spectroheliokinematograph, a decipedalian name which is perfectly digestible if one can find the joints when carving it. "Essentially," Robert McMath writes, "this instrument is a spectroheliograph plus a motion picture camera and, as is well known, such an instrument makes it possible to photograph solar phenomena in the light of some chosen wavelength or single element. The addition of the motion picture camera has made it possible, for the first time, to secure continuous records of solar phenomena. On June 19th, 1934, we were fortunate enough to photograph, in the light of the red alpha line of hydrogen, a rather large eruption from a sun-spot. This film gives a continuous record of the ejection of a large cloud of hydrogen gas, or a 'solar bomb' 19,000 by 40,000 miles in dimension, at the rate of 40 miles per second from a sun-spot, and the subsequent sucking back of some of the cloud into the spot again; the total life of this interesting outburst was of the order of only ten minutes. This picture convinced us that more elaborate equipment was needed in order to carry on the solar work. Ground was broken in July, 1935, for the new solar tower and we hope to be in actual operation by the first of May, 1936."

The solar tower just mentioned by Robert McMath is the higher dome at the left, in the same picture. The two solar towers which are at the Mt. Wilson Observatory are already familiar to all. The solar tower at Potsdam, Germany (often called the "Einstein" Tower because some work on relativity was once done on it), is often shown in photographs, and there is a similar tower at Tokyo. Likewise there is a solar tower at Arcetri, near Florence, Italy. The McMath-Hulbert tower will be the world's sixth, but it will be the most efficient of all, and between the longitudes of California and Italy it will be the only watchman of the sun as the earth rotates. The aim of astronomers is to keep an eye on the sun all of the time, and this of course means providing enough solar observatories geographically distributed so that one of them is always under the sun.

The whole observatory will permit astronomers to learn more about the solar surface—largely an untouched field.

More technical details regarding the McMath-Hulbert Observatory will be found in the department (page 214) which is each month devoted to those of our readers—about 25 percent—who regularly follow the hobby of amateur telescope making.



The McMath-Hulbert Observatory at Pontiac

OUR POINT OF VIEW

Build Airships?

THREE dirigible airships, built in this country, all were wrecked. After the last, the *Macon*, dropped into the sea, there was a widespread demand that we abandon such lighter-than-air craft. In view of the experience of other nations, this demand seemed logical and, as a consequence, the airship enthusiasts have had but a small following the past year or two.

But wait . . . Germany has had one success after the other with her dirigibles. There is the notable example of the *Graf Zeppelin* which is now several years old. She has encircled the globe, flown the North Atlantic, and is now and has been for a year or two engaged in a regular, scheduled service to and fro across the South Atlantic. Another example is the American *Los Angeles*, veteran of the air lanes which was built in Germany and is now retired, the first and only dirigible airship to "die of old age."

Perhaps, then, the dirigible airship principle is not one to be so lightly cast aside. That has been the opinion of many who believe that no possibility should be overlooked in man's stride onward to new scientific triumphs, and that the relatively small toll of any one development should never cause abandonment of further research. After all, no achievement of man has been without its early disasters and its roster of human victims —all forms of transportation, for example—yet, hitherto, each disaster has but spurred research anew. The dirigible airship constitutes another form of transportation, and it may—or may not—have very great potentialities for the future in both commercial peace-time operation and in case of war.

We should not, therefore, condemn the dirigible on the record of a dozen disasters, ghastly though some of them have been, but should heed the advice of those leading scientists on the Science Advisory Board which was named March, 1935 by Secretary of the Navy Swanson, and which numbers among its members: C. F. Kettering, R. A. Millikan, and Frank B. Jewett. This board favors a program of construction for the Navy of large dirigibles. Their thought is that these craft may prove very valuable, and it is for studying their possibilities that new ships should be built. The first built under this program should, the scientists say, be used not as an adjunct to the fleet but as a "flying laboratory" in which might be studied further those questions and problems which were but partially solved in our operation of ships that crashed and the now-retired *Los Angeles*.

It is rather astonishing to us that the country had to ask for such an opinion from scientists, but we will be disappointed, disgusted, if their suggestions are not carried out. Science has never been a weakling to confess defeat in the face of obstacles!

Amateur Missionaries of Science

IN the State of Nebraska it is no longer legal for commercial collectors to dig for prehistoric relics, for the legislature of that state has given the State Geological Survey police power to regulate and control the search for fossils and Indian artifacts. Other states might well copy this kind of ruling from a state which is resolved thus to guard its rich sources of undiscovered scientific data from the irresponsible.

Those few pot hunters who oppose such an invasion of individual liberty—and such it frankly is—are perhaps not so fundamentally wanton as some have asserted. They do not collect and deal in "Indian arrowheads" and similar "souvenirs" because of any scorn of science, but simply because they do not fully sense what it is that they do. They need, therefore, not so often the toe of a boot as friendly instruction in the significance and purpose of science. Might it not then be one of the functions of amateur archeologists to attempt, by the most diplomatic of methods, gradually to convert such collectors into comprehending amateur archeologists, even at the expense of much time and probable initial rebuff? This, rather than the passage of any kind of mandatory law, is the one method which is ever likely in this country to accomplish the desired result, since it is so easy in the big open spaces to defy the law and bootleg the relics of the ancient past. Let every person of scientific learning appoint himself a committee of one as a missionary to make such conversions, for there are not enough professional scientists to accomplish the desired end.

In our rocks and soil there is only one set of evidences of earlier life. It behooves us to deal carefully with them, for when they are gone nothing on earth can replace them. Ancient artifacts and fossils removed from the site and strata of their discovery without scientific record are practically meaningless to science, since they do not relate to its structure as a whole. In a generation or two they find their way to destruction. It is a good thing that Nebraska is staying the hand of the unthinking commercial collector.

Atlantic Flight

AT the time of going to press, it appears that the long anticipated and much talked about conquest of the North Atlantic is soon to be accomplished. As pointed out by Mr. Reginald M. Cleveland, in his article on page 173 of this issue, the lessons that have already been learned through operations on the Pacific airline are being applied in preparation for scheduled Atlantic flights with mail and express, and finally with passengers. In this connection, it is essential that due credit be given to the brilliant and daring minds that, having formulated the plans, are pushing them to completion. To Pan-American Airlines, to Igor Sikorsky, to Glenn Martin, and to the many unnamed engineers and technicians who have given so freely of their energy and genius—congratulations and happy landings.

But transatlantic flight is more than a technical triumph, more than an engineering feat of great magnitude. It opens new avenues for world trade and world peace. As hinted by Mr. Cleveland, successful schedules over the North Atlantic presuppose complete co-operation between the nations directly affected. That the United States is aggressively taking the lead is to be expected, in the light of past accomplishment. That other nations will make strong bids for business is likewise to be expected.

It thus becomes apparent that aeronautical engineers cannot afford to rest on their laurels, content with accomplishment. Peaceful battles will be waged on the airlines, battles that will be won only by those with vision who press ever onward to conquer the impossible. Scientific research has shown the way to higher speed in transport planes, greater comfort and safety for passengers, increased economy of operation; it must continue to improve on all these phases. The foundations have been laid for world-wide airlines that will affect the lives of every civilized person. Upon these foundations must be built a structure strong enough to resist the assaults of international politics and petty nationalistic squabbles. With level-headed business men at the helm, guided by research engineers, we are sure that it can be done.

BONE SURGERY WITH

Grafting Bones is Much Like Grafting Trees . . . Bone from Your Own Body . . . Cut with a Circular Saw . . . Shaped on the Spot with a Bone Mill

By FRED H. ALBEE, M.D., F.A.C.S.
Formerly Professor of Orthopedic Surgery at Columbia University. Consulting Surgeon to the Broad Street, Lutheran Hospital and other hospitals, New York. Founder of the Florida Medical Center, Venice, Florida

BY good fortune we are able to present, on the accompanying pages, an article by a noted, internationally-known bone surgeon, thus giving the lay reader a first-hand insight into a branch of surgery of the most modern and most romantic variety—the repair of damaged bones by means of living bone substance taken from the patient's own body. The author of the article became widely known at the time of the World War, first through six months of operation and demonstration in France, and later in America where he performed reconstructive operations on more than 2000 wounded American soldiers. Dr. Albee is an ex-president of the American Orthopedic Association, and a founder of the International Society of Orthopedic Surgery. He is the author of a large textbook which is widely used by surgeons, entitled "Orthopedic and Reconstruction Surgery," and he has been widely honored within his profession and without.

Bone surgery with metal plates or wire, or with pieces of hard and non-living bone, has long been familiar, but Nature often rejects such foreign substances. To repair living bone, living bone is an ideal material. Many of us think of bone as hard, dry, brittle and somewhat metallic, because most of us see it in that form. But our bones are really alive; they contain pulsating blood vessels and other living equipment. Such bone, rapidly removed from one place (often the convenient shin) and transplanted to another after accurate shaping, unites and grows to

THE origin of grafting of living cells, if recorded at all, is so obscure that I have not been able to trace it. I was not unfamiliar with the process in fruit-trees before I undertook to apply the principles to the surgery of bones. As might be expected, I found much in the study of plant grafting to guide me in bone-grafting. One can safely assume that the principles of plant grafting cannot be violated in the grafting of tissues of a higher form, and that grafting of bone cannot be as readily carried out as grafting of vegetable material.

These postulates arise from the very nature of biological principles and the decrease in adaptability with increase in specialization of tissue. There are three inviolable rules in plant-grafting; the tissues must be applied like to like, the contact must be most intimate, and they must be immobilized in that position. These principles are important in bone-grafting. Moreover, in the more highly specialized animal tissue it is desirable, if not essential, that the graft be autogenous; that is, come from the same individual.

When, in plant grafting, the bark and bud are removed for the scion, a piece of bark of the same size and shape is removed from the host (Figure 1), so that like tissues of the scion will be applied intimately to like tissues of the host and so that immobilization will be facilitated, as well as the early and profuse vegetable circulation from host to graft. Interruption of the circulation of sap in the host is thus minimized.

It is thus evident that the cells of the scion preserve their vegetative and proliferative power. The re-establishment of the circulation is simpler in the plant, but it is obvious that the sap must permeate the cells of the scion, or else the latter will eventually die. In bone, the re-establishment of circulation becomes a problem the solution of which governs the whole question of surgical technique.

IN the plant, as in bone, like tissues are applied to like, because there is a force called by John Hunter the "stimulus of incompleteness," which tends to force tissues to complete a broken surface, and because this force is greater when it is mutual—that is to say, when it is applied to two broken surfaces of like tissue.

Of all the layers in a tree—alburnum, heart-wood, and heart—the alburnum is the important one in grafting, since it is the proliferation of its cells in scion and host that brings about the union. In bone, and especially in long bones, the structure is much harder and more complex, and all the layers — periosteum, cortex, endosteum and marrow — take part, to a greater or less extent, in union. It is for this reason, and the extreme hardness and brittleness of cortical bone (the hard portion), that accurate, power-driven instruments are necessary for preparing graft and graft-bed. Perfect coaptation, so essential to the nourishment of the graft and to its function as a vessel-conducting and osteogenetic or bone-forming unit, can be attained in no other way. If conditions were similar, power-driven tools would be necessary for grafting in the vegetable kingdom as well, in addition to the necessity for doing the work quickly. This last is an additional reason for employing motor-driven tools.

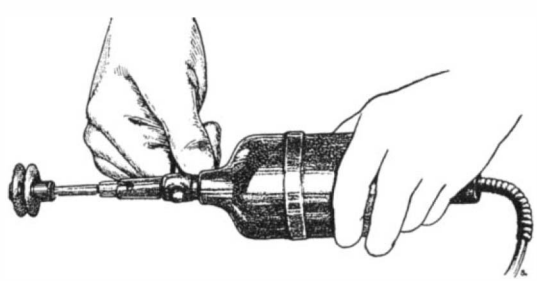


Figure 2: **Twin circular saw chucked in the bone mill, held by the surgeon as in cutting an inlay from the shin bone or other available bone**

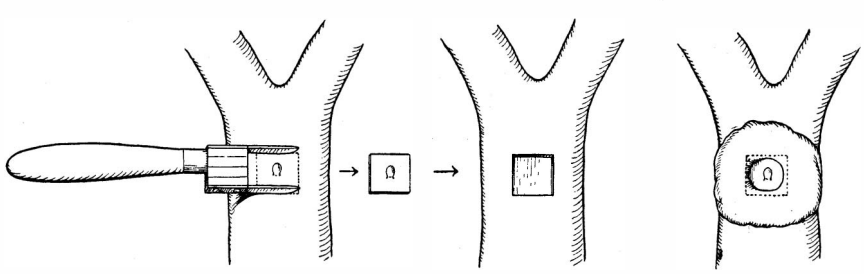


Figure 1: Left: **Removing bark and bud with the double-bladed knife.** *Center:* **The bark removed from the host.** *Right:* **The finished graft, with paraffin**

In plant grafting immobilization is effected in two ways, in addition to the

MACHINE TOOLS

the normal shape of the replaced bone, while the other fills out.

Recently we saw an operation of this kind, in color motion pictures, performed on a tubercular knee joint. With such speed that it seemed like opening a "zipper," the joint was completely exposed and the damaged bone was sawed away from the under side of the knee cap and the joint itself. Loss of the articulation then made necessary the rigid union of the upper and lower parts of the leg, and to accomplish this, two bone dowels were inserted, reaching through the top of the tibia and into the bottom of the femur. First the necessary holes were quickly made by means of twist drills and the bone mill—the patient, under total anaesthesia, being entirely unaware of the fascinating proceeding. Next, the two dowels had to be obtained and shaped. The shin bone was quickly exposed, with scarcely any bleeding, thanks to a tourniquet at the thigh. With the bone mill a pencil of bone about ½ of an inch square and eight inches long was quickly removed and cut in two. These pieces were rapidly fed into the bone mill, emerging as two neat, round dowels, which were then driven into the prepared holes. With no delay whatever the knee and leg were next flooded with antiseptic and closed.

The outstanding impression left by this spectacle was the speed and certainty with which skilled hands performed it. To perform work like this the surgeon must possess the mechanic's sure instincts for close, accurate work.—*The Editor.*

fixation provided by the accurate fit of the scion: the site of grafting is either bound with many layers of fabric or is covered with wax, or better, paraffin. These sealing substances serve as a sterile dressing as well, since they keep out fungi. If paraffin is used, immobilization is just as secure, and light—especially the ultra-violet—is allowed to penetrate to the wounded tissues and especially to the bud, which needs the ultra-violet for the metabolic activity of its chlorophyl.

I do not know the history of the double-bladed knife (Figure 1) which is used for plant-grafting, to ensure identity in size and shape of graft and graft-bed. I first saw it many years after I had designed the twin saw for bone grafting. Its use was demonstrated to me by the late Mr. W. J. Krome, in his citrus grove in Florida. Mr. Krome, after many years as a distinguished engineer, during which he supervised the construction of the Florida East Coast Railway in Key West, retired to indulge his interest in biology.

I did not design my twin saw (Figure 2) from this twin knife, but they were equally a response to the mechano-biophysiological demands of the problem. The twin saws may be regarded as a cutting calipers, since they ensure that the graft will accurately fit the graft-bed.

Plant-grafting and bone-grafting thus have the same objectives and are carried out according to the same fundamental principles. In the plant the only force to be counteracted is that of the wind, and this only when the scion is of large diameter such as in the case of apple-trees. In bones, there is the pull of muscles, both involuntary and voluntary, and the exaggeration of the former by reflex from pain. Fixation and immobilization therefore present difficulties which must be met in a special way. It is necessary to consider bone, therefore, not only as a living tissue with an intricate circulation and metabolic function, but as a rigid piece of material which must be held in place with complete immobilization.

Union of graft with host, however much it may be affected by mechanical exactness, is dependent on the principles

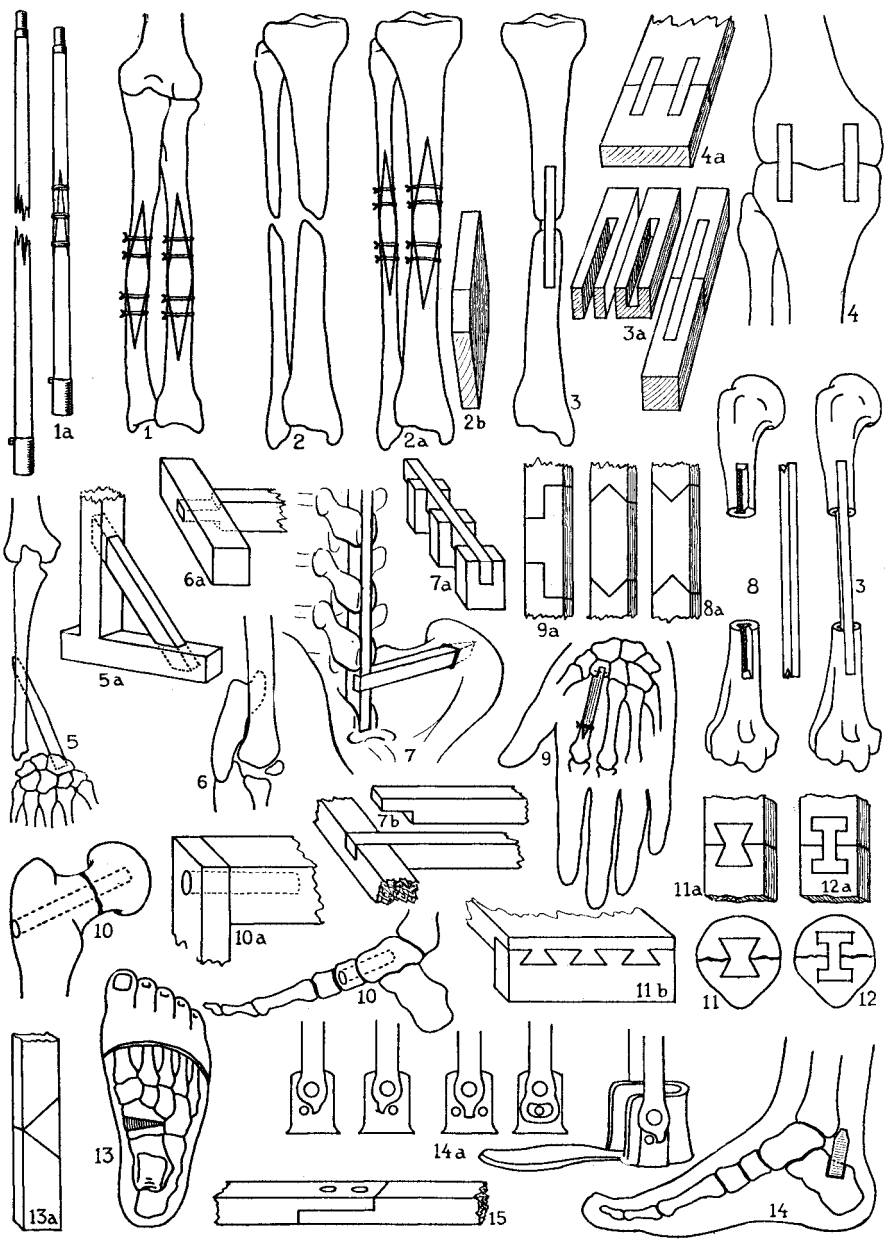


Figure 3: **The fine joinery element in bone surgery—a group of self-evident analogies. Numbers 11 and 12 are keyed-in tension members in broken knee caps which will not join. No. 14 is a stop, made of the patient's own bone, to prevent the foot from dropping. No. 14a is the analogy—a brace made of metal. The bone surgeon must first of all be a born mechanic having marked aptitude**

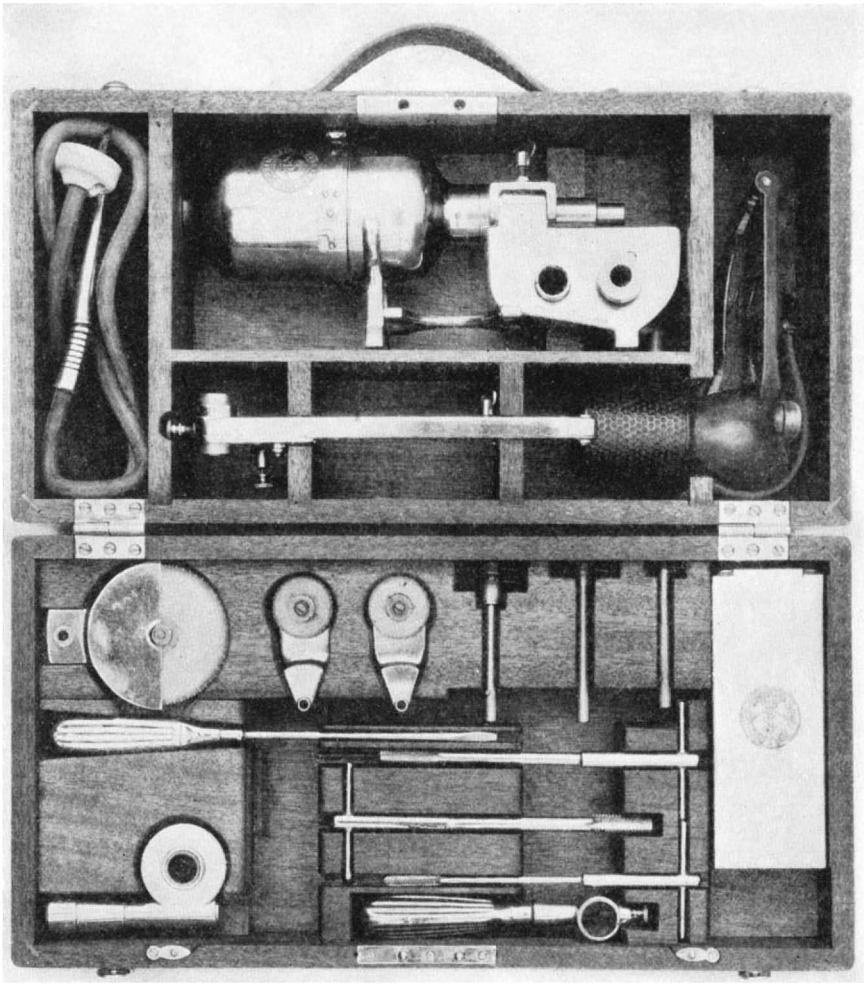


Figure 4: **The bone mill (shown at top of the picture) in its carrying case, with its accessories. Here the apparatus shown in Figure 2 is attached to a base. This converts the hand mill into a fixed lathe, when needed thus. Note chocks on side, for tools used in shaping bone dowel pins at the operating table. In lower half are circular saws, also taps for tapping out holes in patient's bones to receive threaded bone pegs, as shown in Figure 6, at F′**

of biology and physiology that govern the transplantation of tissue as a living, functioning structure. The graft lives if it is supplied sufficiently early and in quantity with blood from the host. Bony union with the host follows in the same way as it does after fracture, by a tissue bridge containing the first deposition of soft callus (soft bone material which is poured out, hardens and unites the bone) and then its impregnation with lime salts.

The graft, having been applied in a way most likely to favor its union with the host, is then influenced by those mysterious processes by which the graft remakes its structure, alters its shape and takes on added volume and strength, in order to accommodate itself to the demands of its new environment. That is, a graft of the general size of a lead pencil, and of any shaped cross-section, when implanted to take the place of a portion of the thigh bone, will take on the characteristics of the thigh bone shaft in every respect; that is, as to strength, size and shape of cross-section, external contour and internal architecture—it will even develop a marrow cavity.

For help with the mechanical problem, one must go to the joiner and study his various forms of mortise and how he selects each according to the mechanical demands of the situation (Figure 3).

My first application of the bone-graft was to the spine in Pott's disease. Since then, it has been used in grafting most of the bones in the body and for a variety of purposes, such as restoration of loss of bone from injury, disease, cancer, healing of broken bones which will not unite, cure of disease, correction of deformities, stabilization of joints, and so on.

The inlay graft in long bones is a perfect example of the ploughed-and-tongued joint, as well as of the application of like tissue to like. It is therefore a complete response both to the biological demands of comparative botany and physiology and to the principles of mechanics that guide the joiner.

The inlay graft (Figure 5) is applied principally to the broken long bones which fail to unite. In typical non-union, the ends of the fragments are avascular or anemic, circulation being deficient for a greater or lesser distance back from the region of the fracture. The bone is hardened and contains few, if any, active callus-forming cells. Its vitality, and hence its power of regeneration, is slight. A bone-graft inlaid into the fragment, reaching far enough back to tap the blood-supply and sources of nutrition and osteogenesis or bone formation in the healthy bone of the host, will bring to the zone of non-union forces which are of the same order as the reparative and osteogenetic power of recently fractured bone. The source of regeneration lies mostly in the soft-tissue structures that sheathe the bone and are enclosed in its medullary canal as well as upon the surface. Hence the graft and graft-bed are at best the full thickness of the bone cortex, so that like tissue may make contact with like, from marrow to periosteum. The vascular channels, especially the capillaries, in graft and host bone unite. Thus the graft obtains nourishment, not only for its own existence and subsequent growth and rearrangement, but for the nutrition of the avascular and impoverished ends of the fracture fragments.

ONE must not picture the graft as persisting in the form of a slender bridge between two fragments of sclerosed or hardened bone. The graft not only throws out callus and ossifies it, but responds to biological demands. It enlarges and thickens almost to any degree and takes on the structure of the host bone. More than that, the sclerosed fragments respond to the demands of restored function. Just as disuse brought about atrophy of the organic structures (vascular and cellular) in the useless fragments, so now restoration to usefulness and subjection to stress stimulate reconstruction of the fragments. Vessels grow in, the dense bone is absorbed and the original structure is eventually restored. It is again Wolff's law of stress, which is only one striking expression of the law governing the relation of structure and growth to function, whether it be in the animal or vegetable kingdom. This law of stress is omnipresent in all living supportive tissue. It determines that the diameter and strength of the trunk of a tree shall be larger than any other portion of that tree. By the same token, the contour, size and strength of the human skeleton are controlled by the stress demands incident to the part. This is also true of a bone-graft used to replace or repair a bone.

In the vegetable kingdom the conformation of the graft and its bed is always some modification of the inlay, whether it be the bud of the orange or the scion of the apple-tree, and so on. In the case of the bone-graft, besides a contact with host tissues that insure its living, there arises a multitude of mechanical demands which would tax

the ingenuity of the most versatile boss carpenter, joiner, cabinet-maker or machinist.

However difficult and exacting the piece of bone cabinet-maker work may be, it is necessary to add a still further fact that is true of all surgical problems the all-important factor of time. The patient is under an anæsthetic, the tissues are open and exposed to the devitalizing influence of the air, instrumentation, and so on. Every instrument or tool must be made sterile by boiling. Bone, being always surrounded by muscles or other soft tissue, is never favored by circumstances comparable to those surrounding material being worked upon in the shop. Because of the hardness, brittleness, and knurly character of bone, and the inability of the surgeon to avail himself of the advantages of the anvil or vise to fix and hold the bone which he cuts, the chisel and mallet are at a disadvantage. Rotary, electrically-driven tools are thus a great advantage.

THE surgeon's difficulties, above indicated, have been largely overcome by making available to him the great advantages of the various automatic cutting tools, electrically-driven. In fact, the writer has designed a bone mill along these lines (Figures 2, 4), which enables the surgeon to shape the one at the operating-table, under surgical sterile conditions, with the same variation and facility that are possible in shaping wood in the carpentry shop or metal in the machine shop. The various motor-driven male cutters (Figure 6, *B*, *F*) shape parts that fit accurately into other parts shaped with corresponding female cutters (Figure 6, *G* to *P*), however quickly the work is done. With this surgical mill, inlays of every variety are rapidly accomplished. These vary from straight inlays to crosses, double crosses, T's, irregular shapes, and so on, of a great variety. The cutting tool for this work is the twin saw, which is as adjustable as the calipers, and in fact is used as a cutting calipers. In this instance the twin saw serves as both the male and female cutter.

The graft may be shaped into any sized peg desired, by means of the lathe attachment. A close fit is assured by selecting the appropriate sized drill (Figure 6, *O*, *P*) when making the hole for such peg grafts. It is important that the fit should be that of the accuracy of a glass-stopper in a bottle, and not that of a cork-stopper, or a square peg in a round hole. Compression may kill bone cells, either in graft or host tissues, or close blood-vessels that should otherwise bring nourishment to the living graft cells. If, by chance, a screw is needed for the human reconstruction, threads are cut upon the peg by pushing it through an electrical rotating die (Figure 6, *F*) which is incorporated in the mill. The drill hole which is to receive the screw is threaded by the corresponding sized tap.

The successful living bone-graft is based upon a tripod of exacting conditions and environment as to mechanics, physiology, and biology. The fit must be exact for a double purpose, to assure fixation and immobilization of the graft as well as the parts it is to repair. This makes for the early and profuse vascularizing of the graft by the penetration into it of blood-vessels from the host tissues.

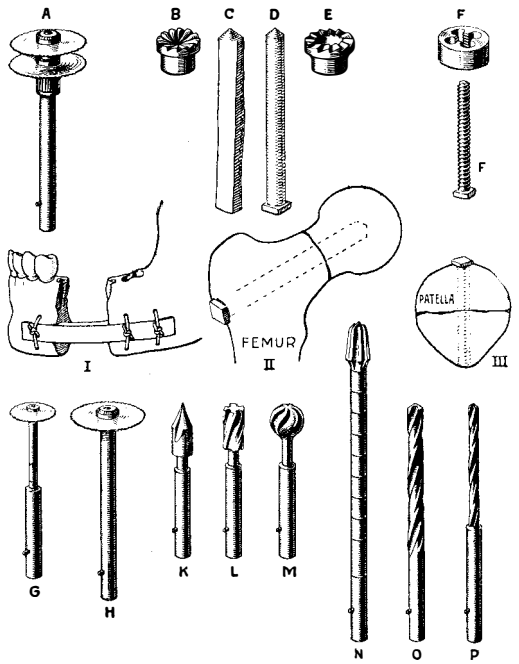


Figure 6: ***A*** **is the twin saw. Speed 3000 r.p.m.** ***B*** **is a miller for pointing the end of a bone dowel, as in** ***C.*** ***D*** **is a dowel after rounding in** ***E,*** **and** ***F*** **is a die for threading a bone screw like** ***F'.*** **Dowels and screws like these are made on the spot from bone removed from the patient's own body and inserted elsewhere in it—all in one minute by the clock.** ***I*** **is a jaw bone, with an inlay taken from the shin. Not only does the living bone unite with the jaw bone, but it grows, filling in the whole gap. Note ordinary machinist's twist drills** ***O, P,*** **for boring holes for dowels**

The query may arise, is this exactitude necessary? The answer is, the proof of the pudding is the eating. By using such methods, many successful results have been secured where operative failures up to 14 have preceded in a single case.

Reparative operations are often done long after the loss of bone, when the urge to repair has nearly or completely ceased. The surgeon must liken himself to a cabinet-maker who finds that he is running short of glue, and then must make his fits all the more exact, so that the glue will be sufficient. In the case of bone, callus is the glue.

The inherent biological urge to repair, which follows an injury to bone, diminishes to a varying degree as time elapses. The fresh cuts made in the bony elements at the operation tend to revivify this to a degree, but it always devolves upon the surgeon to select bone for reparative purposes, of the highest inherent callus-forming potentiality. It is well known that tibial bone has a higher degree of bone forming capability than bone from the spinal column, hence the use of the shin bone for graft material.

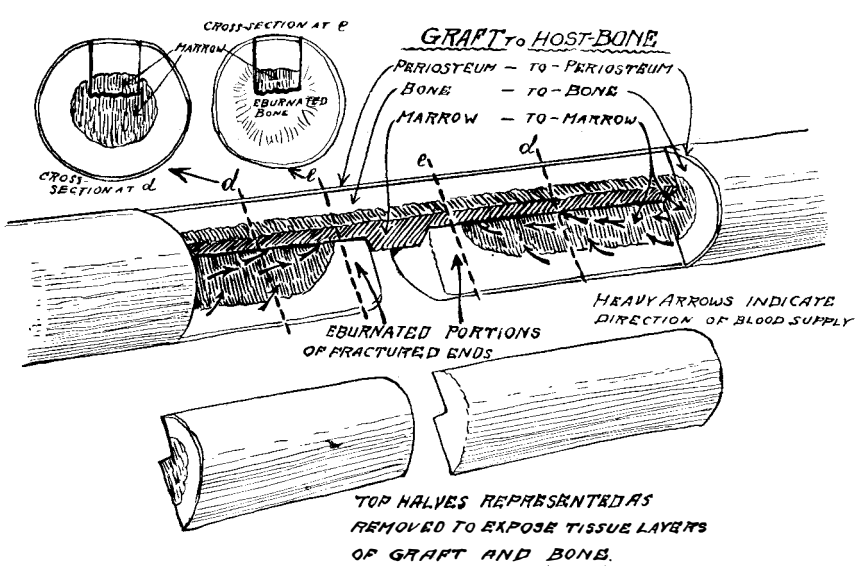
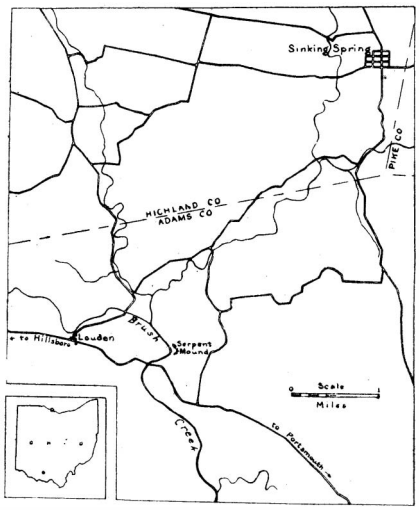


Figure 5: **Showing the principle of an inlay graft. First note old, stubborn, unclosed gap between ends of bones. Next, the long, slender, square piece of shin bone which has been set across it as an inlay. The two pieces in the foreground are not a part of the graft but are merely shown here** ***as if*** **removed, in order to permit showing the situation inside of a bone. "Eburnated"=hard**



Locality of the mound and (insert) a general finder map. Note dot

THE GREAT SERPENT

By CAPTAIN DACHE M. REEVES

LIKE a gigantic snake stretched out to sun itself, the Great Serpent Mound lies on the crest of a ridge overlooking Brush Creek in Adams County, Ohio. With the tail coiled at one extremity of the ridge, the body winds in sinuous loops to an imposing head. At the tip of the head the ridge terminates in a sheer cliff 100 feet above the creek bed, with a narrow rock point jutting out to form the tongue of the serpent.

The most striking view of the Great Serpent is obtained from the air. As one flies over the wooded ridge in summer, the folds of the serpent are disclosed beneath the trees, with the head prominently displayed on the brow of the cliff. In autumn, when the leaves are turning, the ridge lies beneath the airplane in a blaze of color; oranges, reds, browns, and yellows, with the green serpent conspicuous amid its surroundings. On a winter flight the whole ridge is visible through the bare limbs of the trees, with the serpent fully exposed.

The Great Serpent Mound is the largest prehistoric effigy known. Located in a region of natural beauty, it dominates the ridge on which it lies, and presents a most impressive appearance. It is unique among the monuments of ancient America. Two other serpent effigies are available for comparison: The Otonabe mound in Canada and the famous stone serpent of Loch Nell in Scotland, but these latter are smaller and lack the grandeur of the Ohio Great Serpent.

The length of the serpent, following its loops and coils, is 1330 feet, or just over a quarter mile. The width of the mound is 20 feet, with an average height of four feet. The head is highly conventionalized, as is customary in prehistoric art. In the center of the oval is a small mound of stones showing signs of fire. This may have been used as an altar. The fact that no human remains were found in the Great Serpent Mound shows that it was not a burial mound.

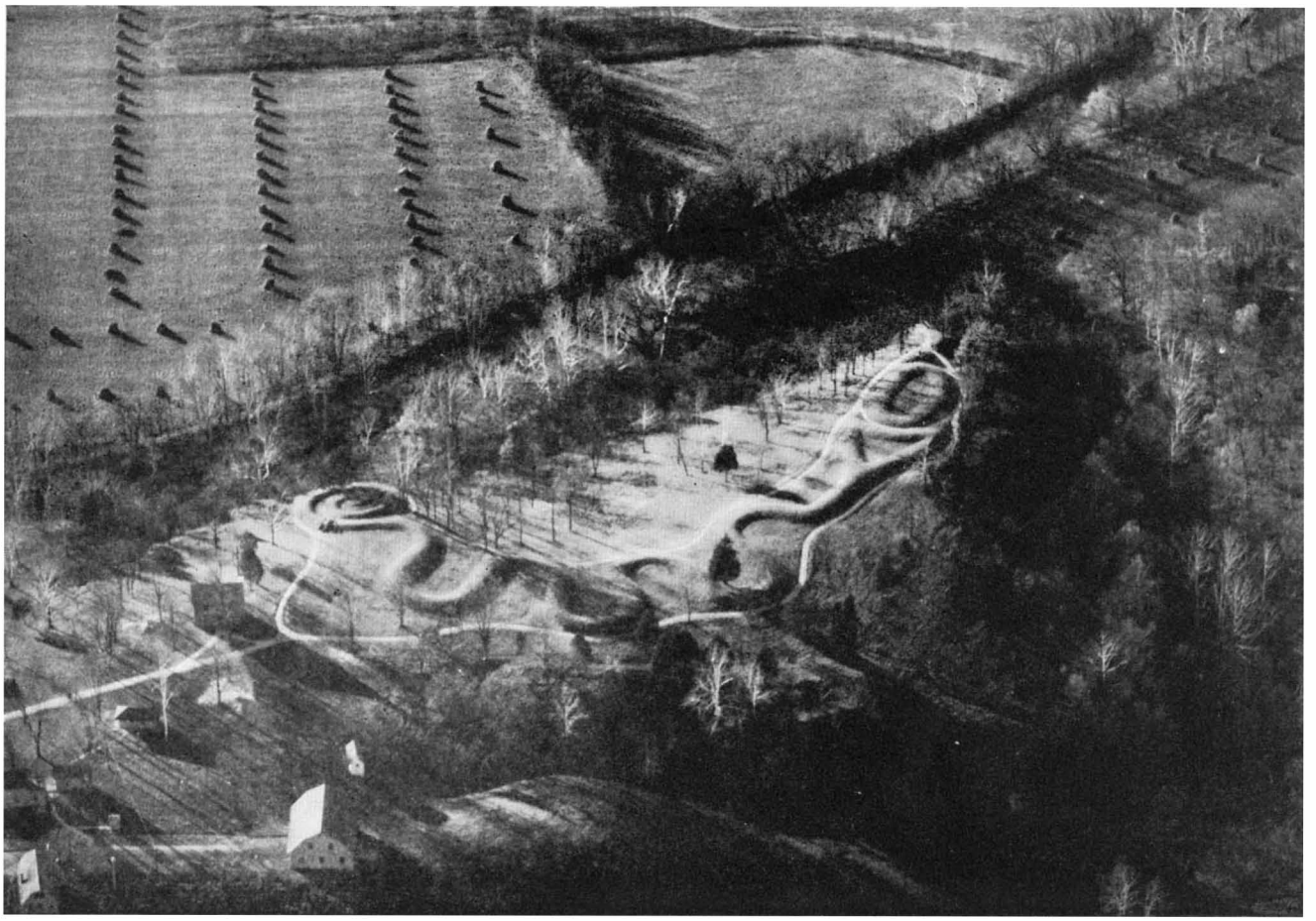
THE construction of the mound required an immense amount of labor. Its builders possessed only crude shell or stone digging tools, and their sole method of transporting earth was in basket-loads. Under these conditions it required a strong motive to undertake such a large task.

The questions naturally arise—why was the Great Serpent Mound built? Who were its builders? When was it raised?

None of these questions can be answered as yet. It is probable that the

The Great Serpent Mound clearly shows in this photograph, taken from the air near the head

Mound in Ohio

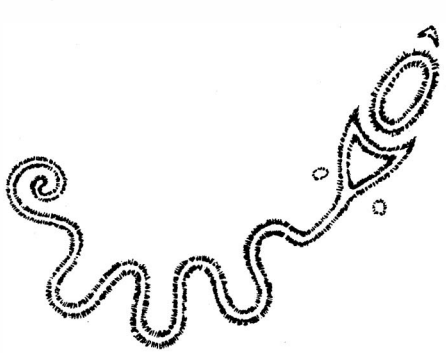


The Great Serpent Mound. The cliff mentioned in the text lies behind the dense trees at the right

Great Serpent Mound had a religious significance to the prehistoric people who labored to erect it. The presumption of serpent-worship is strengthened by noting that representations of the serpent have been found in excavating other mounds in Ohio. A highly conventionalized serpent head executed in native copper was found in the Hopewell Mound. This same mound yielded a rattlesnake carved in stone.

Who built the Great Serpent? The answer is—the Mound Builders. But who were they? From excavations and study of the objects found in mounds, it is possible to learn a great deal about the life of these peoples. As Ohio contains over 4000 prehistoric mounds and other earthworks, a vast amount of material has been collected. This has enabled the identification of several distinct cultures among the Mound Builders.[1]

Even if we determine which of the cultures pertains to the builders of the Great Serpent Mound, the question of age still remains. That its builders were pre-Columbian is clear from the fact that its purpose and history were unknown to the natives living in this area in historic times. Hence its age must be reckoned in centuries. Its exact age is unknown, though there has been much study on this subject. Various estimates have been made, but so far these are nothing more than speculation. It is possible that future discoveries by archeologists will furnish answers to some of the unsolved problems. Yet scientific investigations may fail to determine when the Great Serpent Mound was built. Like the famous Stonehenge on Salisbury Plain in England, the great Ohio effigy may keep its secret inviolate.



Plan of the mound. The two "dots" may represent a horned serpent

Many of the prehistoric earthworks of America have totally disappeared beneath the plow, and the Great Serpent Mound narrowly missed a similar destruction. It had been cultivated for a number of years, and gradually was being worn away when, due to the efforts of Professor Frederick W. Putnam, it was purchased and restored by Peabody Museum of Harvard University. The funds for this were furnished by a few ladies in Boston. Later a deed to the site was transferred to the Ohio State Archeological and Historical Society, and the area containing the effigy is now a State Park. Thus the preservation of this magnificent monument of prehistoric America is assured for all time. On its lofty ridge it rests, a lasting memorial of the hopes and fears of an ancient people who have long since disappeared from the face of the earth.

[1]Authorities on American archeology know of no acceptable evidence that the Mound Builders were other than Indians.—*Ed.*

MINOR PLANETS—II

By HENRY NORRIS RUSSELL, Ph. D.

Chairman of the Department of Astronomy and Director of the Observatory at Princeton University. Research Associate of the Mount Wilson Observatory of the Carnegie Institution of Washington. President of the American Astronomical Society

LAST month's account of the minor planets told far less than half of the story, whose details, even under drastic condensation, fill the portly volume [mentioned last month.—*Ed.*] from the University of California. When an asteroid has been discovered, accurately observed, followed till its orbit can be calculated, and duly listed and named, the specialist's work is not over: In fact, the heavier part of it is just beginning.

Even if a planet pursued exactly the same course about the sun in every revolution—as it would if there were no other planets to attract it—there would be a good deal to do before the demands of accuracy were satisfied. Theoretically, if we had three absolutely precise observations of the position of a planet in the sky—that is, of the direction in which it lay from the earth on three different dates—we could then calculate its orbit exactly, and predict where it would be, any number of years in advance (so long as no outside forces modified its motion).

THE mathematical processes involved, though fairly complicated, are definite, and a day or two of work by a practiced computer should give him the solution—though the novice would probably require a fortnight.

But no human observations are perfectly accurate and, by the very nature of the problem, small errors in the data usually produce very much larger ones in the calculated results. As a simple illustration of such a situation, suppose that we have to determine the circle passing through three points, *ABC*, Figure 1. Our school geometries give the answer: Draw lines through the middle points *D* and *E*, of *AB* and *BC*, at right angles to these lines. These new lines intersect at the center *O* of the desired circle. The school-book diagram looks like child's play.

But now suppose that *B* is very nearly in line between *A* and *C* (Figure 2). We draw our lines through *D* and *E*, as before: They are not quite parallel, and must intersect at some point far beyond the bottom of the page. If we could draw our lines with the absolute perfection assumed by Euclid, all would be well. But it is evident that the slightest error in drawing these lines may seriously alter the positions of intersection, since they cut at what a surveyor would call a very unfavorable angle.

The calculated size of our circle, and hence the length of time which it would take for a point moving at uniform speed to complete a circuit, may be greatly altered by these small errors. Yet it is clear from a glance at the figure that the erroneous circle will lie very close to the correct one between the points *A*

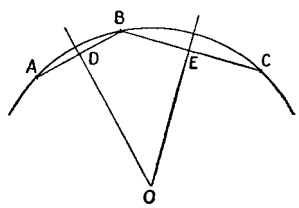


Figure 1

and *C*, and diverge but a little from it for some distance further to the right or left.

In the planetary problem, when our original few weeks' observations cover but a very small portion of the whole orbit, we have the same situation, aggravated by the fact that we have six numerical "elements" to find from our observations, instead of the three which suffice for a circle. If we start with slightly erroneous data, our calculated orbit will predict the motion pretty well for the first few weeks—which will make it much easier to get additional observations of the body. But when we seek to carry our prediction ahead for a year and more to the next opposition, the cumulative effect of the errors may be considerable, and we may have to search some distance from the predicted position to find the planet. If it is not picked up, the accumulated error will be much greater at the next opposition, and so on from bad to worse.

The condensed narrative of the "Research Surveys" are full of such instances: "At the next opposition, the planet was faint, far south, and in the Milky Way"—conditions which practically precluded its finding, before the days of photographic observation. Great labor was often spent in calculating the best available orbit from the existing observations—often not one orbit, but several, assuming various values for the most uncertain of the elements (usually the period). Search along the line marked by these possible positions sometimes picked up the planet: "Palisa rediscovered it after charting 2800 stars." Despite such care, a good many planets were lost—most of them to be found long afterward when wholesale photographic searches became customary.

When a planet is observed at the second opposition our knowledge of the orbit is better, but still imperfect. Only when observations had been made at four oppositions, with the planet in four different parts of its orbit, could the computer rest from his labors, confident that, under the vastly simplified assumptions which we are still making, his predictions could point our telescopes to the planet for a century to come.

BUT, unfortunately for the lover of simplicity, our simplified assumptions are very far from true. The planets are continually pulling and hauling upon the asteroids by their attraction, altering their motions, and causing them to diverge from the predictions of the too-simple theory. During the few months, at most, for which a planet may be observed after its discovery, before conjunction with the sun, the perturbations thus produced are usually small; but, for the reasons already explained, an orbit calculated from the disturbed positions, on the hypothesis that the sun's attraction alone is acting, may be considerably wrong. Here is a new problem to solve: Suppose there was another sun, just like ours, but with only one small planet circling around it: Suppose that at some given instant (during the time covered by the observations) the imaginary planet was at exactly the same distance and direction from the imaginary sun and moving in exactly the same direction and rate as the real asteroid. The only difference between their past and future motions will be that the real planet is subject to the attractions of other planets, and the fictitious one is not. It is then a perfectly definite and straightforward problem (though not an elementary one) to calculate just how much the positions of the two planets, each referred to its own primary, will differ at any other time. When this is known, the computer can make the corresponding changes in the observed positions of the planet, and so, for the purposes of his calculation, abolish the planets, or at least their attraction on the one he is studying. He may then apply the simple theory to the corrected observations, and so get an accurate calculation of the orbit of the imaginary asteroid about the imaginary sun. Applying the differences already computed,

he then finds at last where the real asteroid was, relative to the real sun and its planets. Going on in this way, every new year's observations of the planet enables him to get more accurate values of its period, mean distance from the sun, orbital eccentricity, and so on. Some of the older calculations may have to be revised with the new figures, but finally a really reliable determination of the orbit will repay him for his work.

Here, at last, one might suppose that it would be time for the weary to rest. But, alas, this method of calculation of the effects of planetary attractions—which is known as the method of special perturbations—can be made only step by step, for successive intervals of perhaps 40 days (each step must occupy only a small fraction of the planet's period). The computer may go on as long as he likes; but there are two troubles which beset him. First, even a very small error in the earlier steps (such as arises from working only to six decimal places) will gradually be magnified as the calculations proceed. By keeping continually in touch with new observations as they are made, such errors can be detected and corrected. Second, the step-by-step calculation is costly of time—which is money. This is particularly annoying if a planet is rediscovered after 30 or 40 years. It is a relatively simple matter to calculate an orbit from the earlier, or from the later, observations; but to determine what part of the differences between the two arises from the action of the planets, and whether the rest is interpretable as the result of errors in the observations, demands a plodding calculation for every few weeks throughout the long interval.

WORSE still, the carefully acquired knowledge of the present can be made available for the future only by similar laborious calculations. To stop computing the perturbations is the same as assuming that, after the time when we grew tired, the planets stopped attracting the asteroid, and the positions so calculated may run away so far from the true ones that, after a decade or so, the planet is practically lost. When only a few dozen minor planets were known, it was fairly possible to keep track of them all. Now that the number is far above a thousand, only objects of special interest—such as Eros—can be followed up in this expensive manner. Hence, time and again, in the "Research Surveys," one may read such history as "Accurate ephemerides were discontinued in 1886. The planet was rediscovered" (photographically) "in 1906, 1907, and 1910. The only accurate positions since 1886 seem to be in 1907, '10, '14, '18."

The predicted positions of the principal planets and of the moon, given in the Nautical Almanac, were not derived by step-by-step integration. By very extensive analytical developments of theory, it is possible in these cases to derive "general perturbations"—formulas which express the whole motion, under the combined attractions of the sun and the planets, in such a way that the longitude and latitude in the orbit, and the distance from the sun (or from the Earth, in the moon's case) may be calculated for any given instant—a century hence or two thousand years ago—without figuring out all the intermediate motion.

In principle, the same methods are

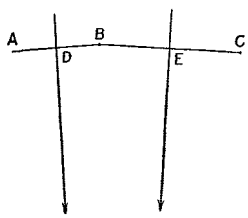


Figure 2

applicable to the asteroids—except perhaps for a few unusually difficult cases. There exists a "mean orbit"—varying steadily, and very slowly, with the time, such that a planet moving around the sun in this orbit will never be very far from the actual one. The difference may be represented as the sum of a great number of periodic terms—each one a perfectly regular oscillation of fixed period and range. Theoretically, the series is infinite. In practice, several hundred terms are required to permit the calculation of the moon's longitude as accurately as it can be observed. For Jupiter and Saturn, the number of terms required is large, for the inner and smaller planets, somewhat smaller.

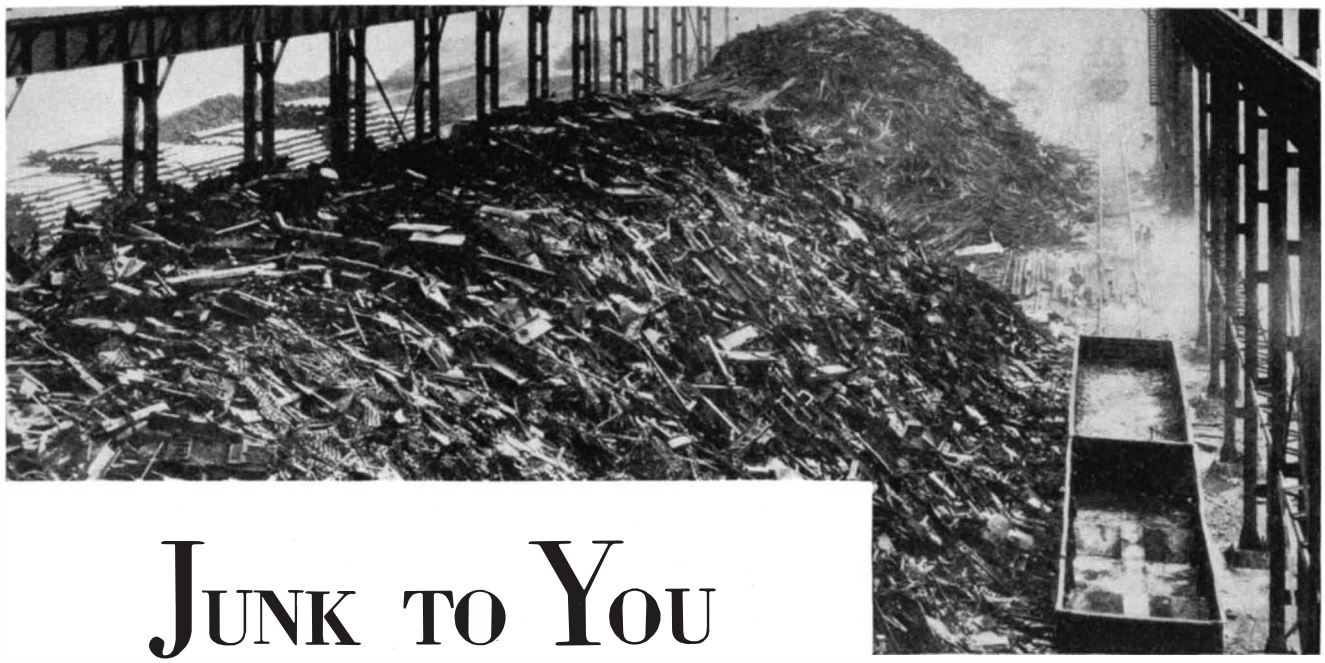
Many asteroids come so near to the massive Jupiter that an enormous number of terms would be required to represent their motion to the highest observable accuracy; that is, to 0.″1 or better. This has been attempted, with considerable success, for one or two minor planets, notably for Vesta, the brightest of them all, but the enthusiastic analysts who have done so well were wise enough to pick out simpler cases, in which the algebraic work would not take more than a few years!

For the great bulk of these bodies it would be chimerical to attempt anything like this accuracy. But it is a wholly reasonable scheme to compute the mean orbit and the largest of the periodic terms—which are not very numerous. By taking these into account, predictions should be feasible, even after many years, with an error of but a few minutes of arc, even in rather unfavorable cases. What is more important, these individual errors due to the incompleteness of the tables will oscillate back and forth as time goes on, but not increase steadily, so long as the job of finding a mean orbit has been well done.

The present hope of workers in this field is to get such mean elements and principal perturbations for as many planets as possible. A surprisingly large quantity of such work, including, with more or less accuracy, about 400 planets, is summarized in the "Research Surveys," and it is stated that at least 75 percent of the 1300 planets which had been numbered when the census was closed could be handled in the same manner.

The work of calculating the perturbations, comparing with the observations to find a mean orbit, and from this deriving the final results, is a very considerable task for a single planet. To do so for a thousand planets is an enormous job, which is likely to remain long incompleted despite the fact that tables have been prepared which shorten the labor.

THE two hundred or three hundred harder cases are of various types. One example is (499) Venusia. This planet has a period of 7.83 years, a high eccentricity (0.22) and a small inclination (2 degrees). At aphelion it is 450 million miles from the sun, and less than 40 million from Jupiter's orbit. Should the planet come to this point while Jupiter was at its nearest, Jupiter would appear, to an observer on its surface, as a disk 480″ in diameter (one quarter of the size which the sun looks to us), and the sun itself only 5% as big! At this time, Jupiter's attraction on the planet would be almost 1/7 as great as the sun's. The asteroid would move at 12 km/sec, a little slower than Jupiter (13.1), so that the two bodies would remain near one another for a long time—about two years. Such an encounter would produce very extensive changes in the planet's orbit. It would be some time, however, before they happen, for at the last conjunction of the two (in 1918) Venusia was at perihelion, 3.1 astronomical units from the sun, and more than 2 units from Jupiter. The planet catches up with Jupiter once in 23 years, but it will be more than two centuries before a really close approach takes place. It is doubtful whether the general infinite series, which give an adequate expression for the perturbations in ordinary cases, would remain convergent in such extreme circumstances. The step-by-step method, however, will handle any motion—short of a case in which the planet actually collided with Jupiter—and, even then, would enable us to calculate the exact circumstances of the collision—so that there is no fear that the problem may get beyond the power of an analysis, provided, of course, that people with good telescopes are interested enough to keep on observing the planet, and others with good heads for figures care to keep up with the calculations.—*Princeton University Observatory. February 4, 1936.*



Just a pile of scrap metal—but destined to become an important factor in the production of steel

JUNK TO YOU

A Billion-Dollar Industry in Scrap Metals . . . Revolving Resources Save Ore and Coal . . . The "Alloy Age" Has Introduced New Problems

By PHILIP H. SMITH

SCRAP metal may be simply junk to you, but it is fast becoming our primary source of many metals and is already our one great revolving industrial resource.

Scrap is the biggest thing in steel. Certain mills now produce steel the year around without using a single ton of iron ore. And that saves both ore and coal. Scrap goes into the manufacture of non-ferrous products, too, and so is postponing the day when high-grade deposits of copper, lead, and zinc will be exhausted.

"Simply junk" is an important factor in controlling the rate at which obsolete industrial equipment is replaced. When scrap prices rise so does the value of old machinery and then replacements are stimulated.

Behind scrap is a billion-dollar industry, composed of thousands of small dealers and hundreds of big ones who operate independently, but who in the aggregate form a closely knit organization. Its sole function is to keep the metals in circulation. It collects a vast array of worn-out products, sorts them, grades them, sluices them into great "surface mines," ready for use again in the manufacture of new products.

Until quite recently, making metals go 'round and 'round was relatively simple. The scrap dealer merely sorted the ferrous and non-ferrous types and sold them for what they were. But the metallurgy of alloys is changing all that and making complex operations of both the handling and the use of scrap. What does the scrap dealer or the mill user do with alloys?

Before we can answer this question, which has so great a bearing upon the scrap industry and the entire metal-using world, a few definitions are necessary as well as a brief glance at existing practices. It is what is being done in the laboratory and the mill today that tells what lies in store for scrap.

BREAKING scrap down into classifications provides two basic types—"home" and "open market" scrap. The former, representing normal wastes in production—such as cut-off ends of ingots, residues of fabrication, and the like—goes right back into production. The latter comes closer to being junk as we know it because it includes all reclaimed metal. This type is further classified into non-ferrous material, which is routed to refiners, and into ferrous scrap which finds its way ultimately to steel and wire mills and foundries. Of the ferrous type there are 75 grades, but less than a dozen are universally recognized.

The recovery of non-ferrous metals from scrap is a highly organized, efficient business. Mining companies as well as independent refiners are engaged in it and their output is substantial. Old copper, for example, represents about one third of the total annual copper production. Lead ranks next to copper as a refluxing or circulating metal, and then follow aluminum, zinc, and tin.

Copper comes from a thousand sources and goes back into use in as many and as varied ways. Though copper is virtually indestructible and seemingly could reflux to balance with consumption, this is not the case. Home scrap eventually equals all consumption because it goes back into use, but there are losses from wear and through the dissipation of small objects. Supply is, of course, controlled by the obsolescence rate of copper products and this may or may not balance with consumption at any given moment. When trolley lines are abandoned, their lines are salvaged to augment scrap piles, but there are also busses taking their place and the busses have copper radiators. The balance may thus be restored very quickly.

Copper use today is significant because of the way in which it will affect the scrap market years hence. The growing practice of alloying with copper will bring no greater amounts of copper to the refiner but it will bring more alloy scrap to the steel mill and create a problem in steel production.

Lead does not return to scrap in proportionately as great amounts as copper due to its many dispersing uses. It goes into paint pigments, foils, bullets, and gasoline anti-knock compounds and never comes back. About 75 percent of all the lead in storage batteries refluxes with periodic regularity and can be counted upon for more than 100,000 tons annually.

Aluminum is still too young a metal to give much account of itself in scrap markets. But it is indestructible and presumably will reflux much as copper does.

Both zinc and tin scrap are mostly of the "home" type and little reaches the open market for reclamation. However, the phenomenal development of zinc die castings[1] presages recoverable metal in the near future; castings are already finding their way back to smelters for manufacture into zinc oxide.

The ferrous group, iron and steel, reflux to a high degree and scrap now constitutes about 50 percent of new steel content, though the percentage has been known to run as high as 64. All manner of scrap is used, but big units are preferred, both by the collector and the mill. A battleship, for example, being in itself a mine of various metals in easily handled form, is considered desirable scrap. Henry Ford thought a fleet of 199 war transports worth 1,600,000 dollars as material for "flivvers," and the British went to a great deal of trouble to raise the German fleet sunk at Scapa Flow to get metal which was valued at 13,000,000 dollars.

WHAT the big users want and regard as choice scrap are solid chunks of alloy-free metal and that, more than anything else, means, to the steel industry, railroad scrap—rails, old freight cars, and locomotives. But here is where a great change is coming over the scrap situation.

In 1924, the railroads of this country consumed 28 percent of the total steel output. Ten years later they took only 10.5 percent, and last year a mere 7 percent.

In 1924, the automobile industry accounted for 10 percent of the total steel consumed. Ten years later the figure had risen to 21 percent and last year to 25 percent.

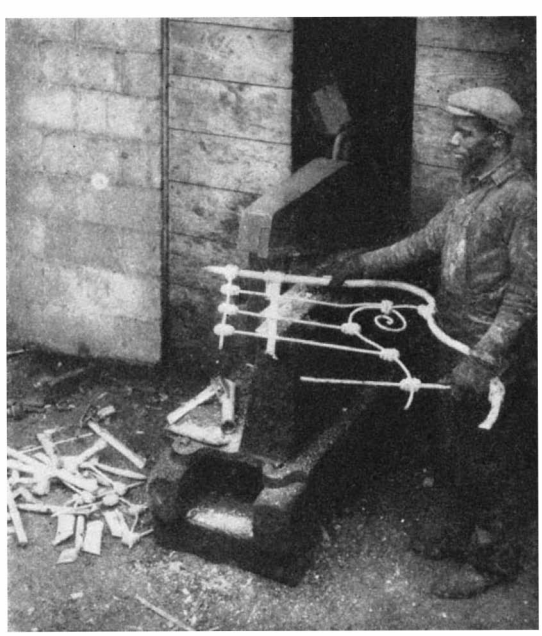
Supplies of choice railroad scrap are definitely shrinking while automobile scrap, regarded as "poison" by the majority of steel producers, is mounting. Automobile scrap is unpredictable. A vehicle stripped of its radiator, lamps, battery and small fittings from which are recovered copper, lead, and zinc, leaves an engine block for the foundry, sheets coated with paint, and steel alloyed with a large number of metals such as chromium, nickel, vanadium, and molybdenum. The sheets can be used in small doses, but the alloys will upset the control of a melt unless their presence is definitely known and taken into consideration.

Here is a dilemma from which several possible escapes come to mind quickly. The first is for the steel mills to revert to ore for their raw material. Unfortunately this won't do because the economic reasons for using scrap remain operative. Scrap is virtually a surface mine, located nearest to the points of consumption, and freight differentials cannot be ignored. Nor can the mills overlook the two tons of coal and ton of limestone required to make one ton of steel from two tons of ore, with all that the process involves in material and handling costs.

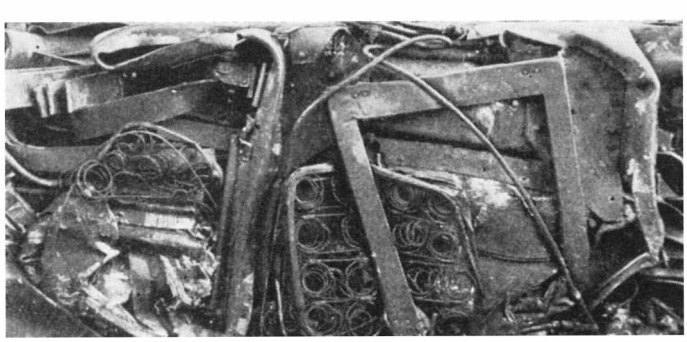
A second solution would be to draw more heavily upon other types of scrap —bridges, old machinery, and the steel frames of buildings. These are already being used and while they would provide a solution, it would be temporary as will be shown later.

A final suggestion would be to ignore the implication of statistics and point out that the present situation can not last; there will be, as railroad finances improve, a revival of replacement which will throw upon the market adequate amounts of choice scrap.

One does not have to be an automotive visionary, however, to realize the ineffectualness of this solution. A revival of railroading would not necessarily restore the former equilibrium. There would be a substantial reflux of railroad scrap for many years, but a thoroughly modernized road will not reequip with identical materials. It, too, will utilize metallurgical knowledge to create a future scrap problem; witness the new light-weight trains.



Powerful shears for cutting up metal scrap



Scrap metal pressed into a solid chunk

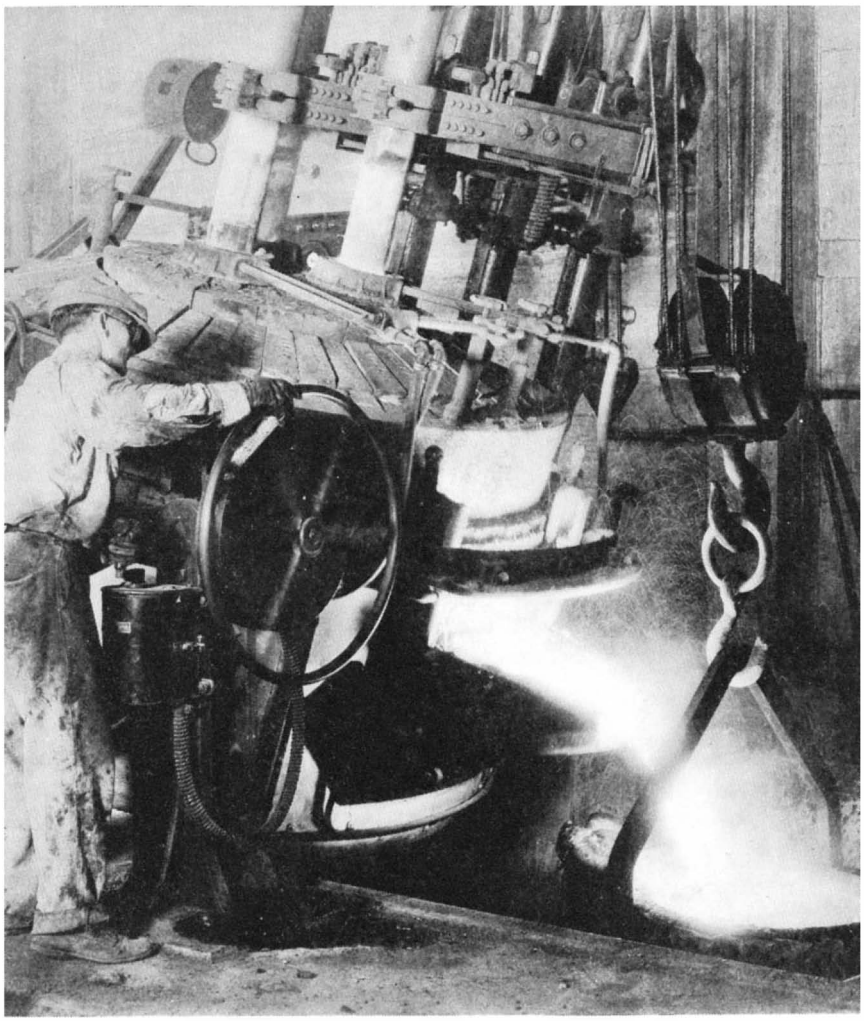
THE steel producer who succeeds in dodging the automobile only postpones the day of getting run over because, important as is the isolated scrap problem raised by the automobile, its real significance is in calling the change on the entire steel and scrap industries. We are entering an Alloy Age and in another 10 years we may see alloy steels accounting for one third of all the steel produced. The problem is greater than one of melting up old motor cars; it is one of using alloy scrap no matter what its source.

Though the steel industry may be charged with being backward about the use of alloy scrap, it has been forward in recognizing the onrush of the problem. For several years joint studies have been carried on to determine what residual metals were appearing in scrap and how rapidly the content is increasing, as a preliminary to meeting the problem in production. It has been proved that residual metals are increasing slowly, copper more rapidly than any other metal, and the opinion can be expressed that the increase will accelerate as alloy steels penetrate new fields.

Just take machine tools, for example. When cemented carbides began to demonstrate their essentialness to high-speed production, they also showed that existing machine tool equipment couldn't stand the gaff. So today we have a new crop of machine tools employing alloy steels to give added strength and rigidity without undue increase in weight. Now if machine tools maintain their rate of improvement, obsolescence will convert them into open market scrap within a very few years. And so it goes: agricultural implements, building construction, and almost every known industry is taking to alloy steels. The automobile industry is only the trumpeter in the march of metallurgical progress.

Alloying aims to increase strength without increasing the weight of a product, but it does not stop there. Corrosion resistance and strength with

[1] Scientific American, May 1935, page 254.



Pouring a melt of scrap from a modern electric furnace

greatly reduced weight are the real aims of the Alloy Age, and this development implies wider use of alloys and some substitution with such light weight, nonferrous metals as aluminum and magnesium.

FACED with the Alloy Age, what are the scrap and steel industries going to do about scrap? About the only contribution the scrap industry can make is to do a better job of sorting and grading in order to be able to offer the steel scrap buyer more uniform grades. It has even been suggested that scrap dealers melt down their material into pigs to be sold with known specifications, but this is an elementary, though important, step. After proper classification and grading has been done, there still remains the problem of use in the mills. Metallurgy will have to take over the matter at this point and the accomplishment which research has made to date is being reflected in work with the electric furnace.

All-scrap charges, high in alloy content, have been used in the open hearth type of furnace, but only when making such common products as nails, barbed wire, and woven wire field fence, where a wide latitude is not detrimental to the product. When better grades of steel were sought, practice has been to use quite a large percentage of pig iron or hot blast-furnace iron in the charge. Now comes the electric furnace which uses all-scrap charges for some of the better grades of steel, though by no means all of them, and there are certain mills which are operating without the use of a single ton of iron ore or pig iron. Records of mill operations show that such miscellaneous scrap as turnings, borings, flashings, clippings, punchings, foundry returns, and light scrap, is being used in the production of steel, the electric furnace permitting control of the reducing or non-oxidizing atmosphere and slags to produce a well degasified product and one more resistant to atmospheric corrosion by virtue of greater solidity.

In the manufacture of cast irons, the electric furnace can be operated with all-steel or all-iron scrap charges, whichever is available and cheapest. Oxidizing and reducing conditions are under control and an analysis of the charge can be made during the heat. Should adjustments be needed they can be made while the charge is still in the furnace. Largely because of the electric furnace, cast irons are now being produced with a tensile strength of 40,000 pounds per square inch, whereas a strength of 25,000 pounds was thought excellent a very few years ago.

For the scrap industry to put up with alloys leaves them in the class of liabilities and, of course, the grade of steels produced is definitely limited. An advance, therefore, is to utilize the alloys so that they become an asset, and this, too, is being done. When the alloy content is known and the use is predictable, certain alloyed steels can be produced. Both nickel and molybdenum alloy scrap can be remelted in an electric furnace without loss of the alloy and this explains why a few steel producers regard some alloy scrap as premium material.

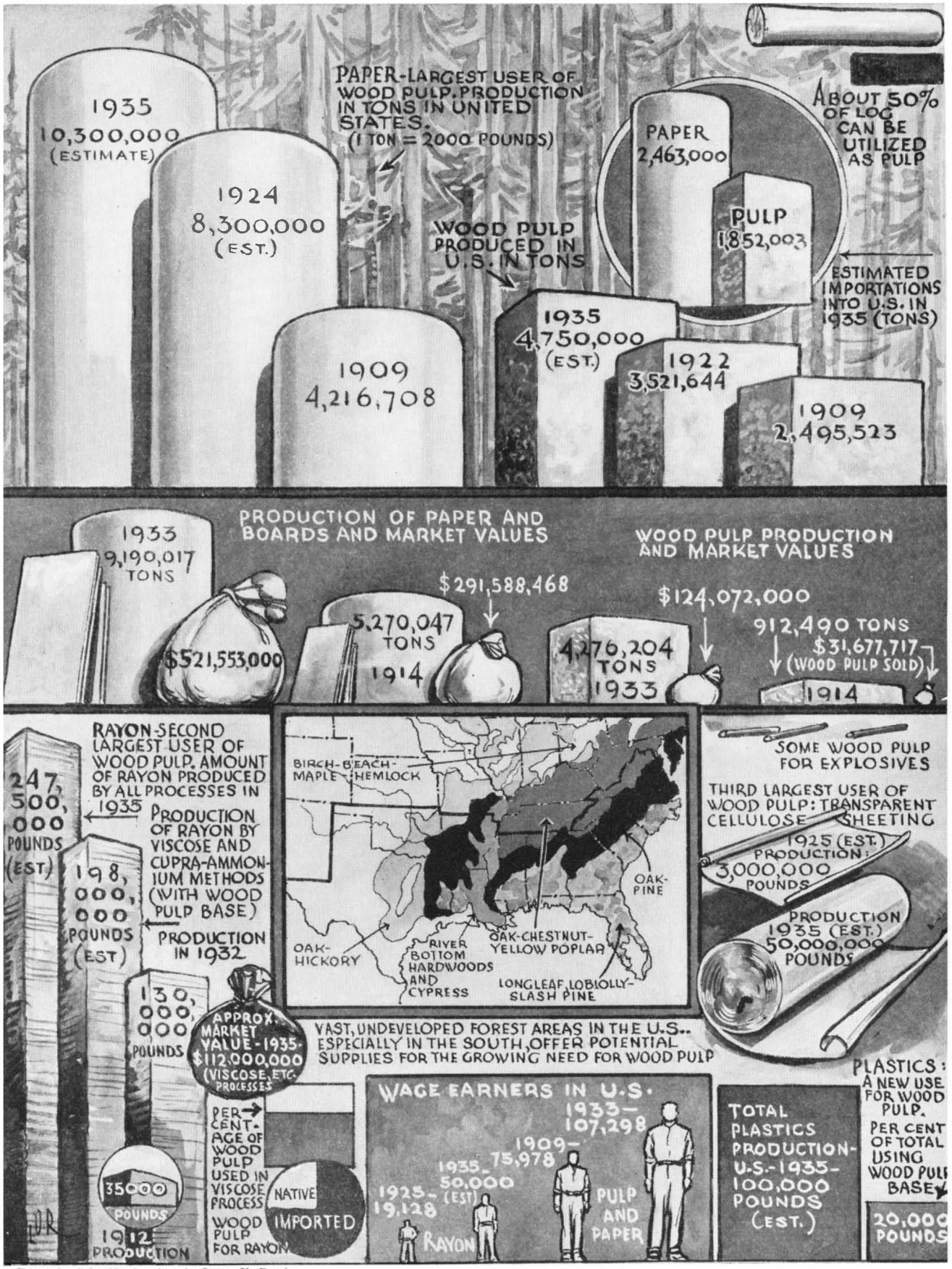
CRITICS may raise the cry that the electric furnace is a very insignificant factor because the furnace unit is small and accounts for a proportionately small tonnage. This is a half truth. The whole truth is that these furnaces are increasing in number and their rapid operation gives a large output in the aggregate. If electric power costs go lower, they will become even more dominant and they can be counted upon to provide an outlet for a large scrap tonnage.

The Alloy Age is also becoming a "Tailor Made" steel age, with special products made for special uses and each and every use dictating its own product specifications. This implies that there will be more pressure than ever to control processes and to know within very close limits just what goes into the melt. It is a demand that works counter to the use of scrap and particularly to the scrap of the future.

Knowing what is going on in laboratories, we might hazard the opinion that a means will be found for drawing off the unwanted alloys from the furnace while in the molten state. This is a dream of metallurgists and there are many working to translate it into reality; but the whole scheme is still too nebulous to warrant placing any dependence upon it. It is much more likely that the solution will be approached through an improvement of present technique—through finding more and more ways of making alloy scrap predictable through an accumulation of mill experience.

Here, in the scrap situation, is a splendid example of industry faced with a problem which it cannot dodge. Here is a challenge worthy of full and prompt acceptance; and just because the demand to meet it is so imperative, there will be a satisfactory solution. When that time comes, scrap metal will be everywhere accepted as our national resource Number One.

Photographs courtesy Institute of Scrap Iron and Steel, Inc.; Northwestern Barb Wire Co.; and Pittsburgh Lectromelt Furnace Corp.



Drawn for Scientific American by Logan U. Reavis

THE AMAZING GROWTH IN THE USE OF WOOD PULP

THROUGH the efforts of chemical and mechanical engineers, there has been a steady increase in the use of wood pulp in many fields other than the production of paper. The drawing shows the important phases and figures. It is readily apparent that the future uses of wood pulp will depend largely on intelligent re-forestation and intensive chemical research directed toward the utilization of less favorable types of trees such as abound in the East and South.

TRISECTING THE IMPOSSIBLE[1]

Why the Angle Trisector is Wasting His Time . . . the Problem is Insoluble—Demonstrably So . . . But the Perennial Aspirant Works On and On

By A CONTRIBUTING EDITOR

ALL of the stir which invariably occurs whenever the newspapers report that John Doe, "a humble man with none of the advantages of an advanced education, has succeeded in trisecting any angle, a problem which has baffled the greatest of mathematicians to date"; or more recently, that the eminent Blankety Blank has succeeded "where generations of mathematicians have failed"—finds its ultimate origin in the aversion of Plato (429-348 B.C.) for all geometrical constructions involving the use of instruments other than a ruler and compasses. By a "ruler" we mean here a straight-edge *without graduations.*

Hippias (about 420 B.C.) devised an instrument which would construct a curve, called the quadratrix, by means of which he could trisect an angle, or indeed divide it in any given ratio. However, Plato's influence over his contemporaries was so great that the restriction to straight lines and circles not only became the rule of the day, but was observed by his successors, including Euclid (330-275 B.C.), and the search for a method of trisecting an angle under this restriction was begun. The search has continued, in spite of the fact that it was shown by various writers during the past century that such a construction is impossible when one is restricted to a ruler and compasses.

It is the purpose of this article to outline the argument by means of which the impossibility of this construction is demonstrated. On account of its complexity the argument will not be given in detail, but frequent references will be cited, in order to enable the advanced reader to obtain proofs of assertions not completely proved here. Notable efforts have been made by Felix Klein, Leonard E. Dickson, and others to bring this matter to the public eye, in the hope of reducing the number of individuals who waste their time trying to discover this impossible construction.

Special attention should be drawn to Professor Dickson's proofs (see the bibliography at the end), not only for their frequent occurrence in mathematical literature, but also for the variety of methods he has employed; it is his thesis that such an important question should be dealt with in more than one way. The present writer wishes to acknowledge his great indebtedness to the previous work of Professor L. E. Dickson.

THE ancient angle trisection problem, provably insoluble, is regarded as a "chestnut," both by mathematicians and the editors of scientific journals; why, then, is a discussion of it dignified by insertion here? Because, properly or improperly, this age-old problem periodically becomes news every time an aspirant to its solution manages to convince a local reporter that he has solved it, and thus gets the "news" put on the wires all over the nation—which happens about once a year; because millions of wondering newspaper readers are thereby genuinely puzzled; because many of our readers, willing enough to believe the mathematicians who say the problem cannot be solved, would nevertheless like to know why; and finally because the demonstration will be an answer to all those who, challenged by assertions as to the futility of the attempt to trisect an angle, have continually sent this journal their solutions throughout the past several years. Unfortunately, as is the case with the Einstein theory, the demonstration cannot be explained entirely unmathematically.

There are at least three kinds of angle trisectors: first, those who sincerely hope they can solve this problem; secondly, those who misunderstand the terms on which it is based (compass and straightedge but *no measuring*); third, some who believe they can do what others cannot do, to put it as charitably as possible.

The accompanying article is definitely not a bid for solutions; just as in the past, we still cannot undertake to examine them. This is not merely a problem whose solution has not yet been found; it is one which is *provably* insoluble. No doubt the energy which has been devoted to the many attempts at solution which have been sent us would have dug the Panama Canal or moved the Pyramids of Egypt to Antarctica.—*The Editor.*

No doubt the reader wonders why, if proofs are available, books on elementary plane geometry do not devote a section to demonstrating that angles cannot be trisected, polygons of seven and nine sides cannot be constructed, and so on. The reason is that elementary plane geometry is not powerful enough to answer this question; in order to prove that a given problem for construction was insoluble it would be necessary to examine every last one of the infinite number of imaginable constructions, one of which might be successful. This is especially unfortunate because many people who dislike other forms of mathematics are fond of plane geometry; it affords excellent mental discipline and is excellent training in clear thinking, since it requires a special procedure for each and every problem attacked.

Descartes realized that a method, such as the one just mentioned, which required a special procedure in each case, possessed a great weakness as far as research was concerned, and pointed out that by analytical geometry it was possible to lay down a few simple rules by means of which a given proposition could be proved or disproved immediately. Plane geometry has its merits, and ought not be discarded; it will often yield an elegant proof of some proposition that has been found to be true by other methods, but it is weak in connection with propositions not known to be valid beforehand. Consequently, before turning to the special problem at hand, it is necessary to formulate some of the usual geometric ideas in terms of analytical geometry.

"Analytical geometry," according to W. W. Rouse Ball in "A Short Account of the History of Mathematics," "does not consist merely, as is sometimes loosely said, in the application of algebra to geometry: that had been done by Archimedes and many others, and had become the usual method of procedure in the works of the mathematicians of the 16th Century. The great advance made by Descartes was that he saw that a point in a plane could be completely determined if its distances, say x and y, from two fixed lines drawn at right angles in the plane were

[1]An abstract of a paper presented before the Lawrenceville Science Club.

given, with the convention familiar to us as to the interpretation of positive and negative values; and that though an equation $f(x,y)=0$ [for example, $7x+2y+6=0$] was indeterminate and could be satisfied by an infinite number of values of x and y, yet these values of x and y determined the co-ordinates of a number of points which form a curve of which the equation $f(x,y)=0$, expresses some geometrical property; that is, a property true of the curve at every point on it.

"It was at once seen by Descartes and his successors," Ball continues, "that in order to investigate the properties of a curve it was sufficient to select any characteristic geometrical property as a definition, and to express it by means of an equation between the (current) coordinates of any point on the curve, that is, to translate the definition into the language of analytical geometry. The equation so obtained contains implicitly every property of the curve, and any particular property can be deduced from it by ordinary algebra without troubling about the geometry of the figure. The points in which two curves intersect can be determined by finding roots common to their two equations. . . ."

In this day and age, when the subject of graphical representation is being taught in high schools, and graphs are being used to portray business fluctuations, the above quotation will very likely recall to mind a subject studied somewhere or other once upon a time.

THE Straight Line and the Circle: Since we are interested in dealing with our problem in terms of Euclidean geometry, it is necessary for us to make certain assumptions, with Euclid, upon which to build our analysis. Therefore we say: Let it be granted that

1) A straight line may be drawn from any one point to any other point.

2) A terminated straight line may be produced to any length in a straight line.

3) A circle may be described from any center at any distance from that center.

4) All right angles are equal.

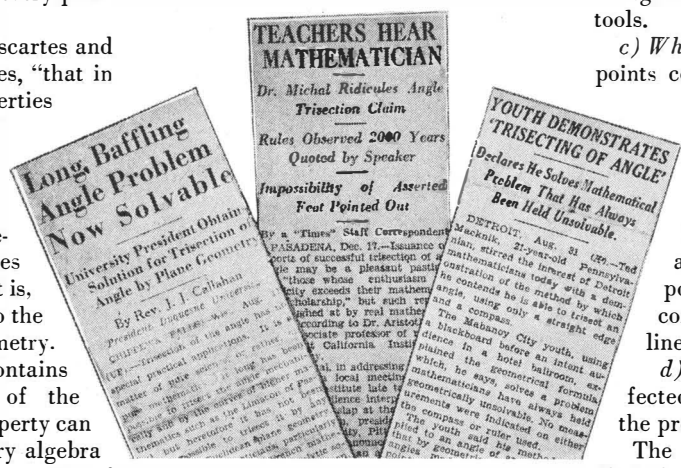
5) If two straight lines in a plane meet another straight line in the same plane, so that the sum of the interior angles on the same side of the latter straight line is less than two right angles, then the two straight lines will meet on that side of the latter straight line.

From these postulates, together with some axioms and definitions, Euclid builds his entire structure of plane geometry. If we are to examine the problem of the trisection of an angle in terms of analytical geometry, it is evident that first we must obtain the analytical equivalents of Euclid's straight lines and circles.

It is shown in books on analytical geometry that any straight line whatsoever in a plane can be described with reference to a fixed pair of rectangular axes in the same plane by the equation

(1) $Ax+By+C=0$

in which both A and B cannot be zero simultaneously. If one of these is zero, say A, then the line is parallel to one of the axes, in this case parallel to the X-axis. If C is zero, this means that the line passes through the point of intersection of the axes, called the origin. Since both A and B are not zero in any given case, by dividing through by the one different from zero, say A, one obtains two ratios, in this case B/A and C/A, and both of these ratios must be known in order to determine the line uniquely. This is the analytical analog to the well known geometrical fact that it takes two points to determine a straight line uniquely.



Similarly, in analytic geometry it is found that any circle can be described by appropriately choosing the values of D, E, and F, in the equation

(2) $x^2+y^2+Dx+Ey+F=0$

Here it is necessary to know the exact values of *three* constants in order to determine the circle uniquely. This is in accord with the geometrical fact that if three points on a circle are known, then it is completely determined (that is, one circle and only one circle can be constructed so as to pass through three points not on a straight line).

The Nature of a Construction: In order to investigate the exact nature of a geometrical construction it will be helpful to consider a specific problem. Therefore, let us suppose that we have been asked to construct a straight line parallel to a given straight line and passing through a given point not on the given line. The complete solution of this problem may be divided into distinct steps:

a) What data do we possess? We are given a definite straight line, and a definite point not on this line. Since two points are required to determine the straight line, our data consists of *three points* (say A, A', and P) whose locations we know exactly.

b) What tools have we at our disposal? In the assumptions we have made we grant that it is possible to draw a straight line through any two known points, and that it is possible to construct a circle of given radius about a given point as center. Therefore, since we do not wish to increase the number of our assumptions, we must limit ourselves to *straight lines* and *circles*—these are our tools.

c) What do we wish to do? Since two points completely determine a straight line, we see that our construction requires the location of a *new point*, say P', such that the straight line PP' will be parallel to the given line AA'. How to locate not just any point, but some particular point which will determine (in conjunction with P) the desired line, is our problem.

d) A construction having been effected, we must prove that it solves the problem exactly.

The features of the above analysis that should be noted carefully are: 1) the exact knowledge of *certain points* contains all of the given information, and 2) the solution of the problem reduces to locating a *special new point.* This type of analysis carries over to any construction whatever, so that any construction which is sought depends for its solution on the location of an appropriate new point (points) which is to be located as the intersection of two straight lines, one of the intersections of a circle with a straight line, or as one of the intersections of two circles with each other, all the circles and straight lines used in the construction being determined by given points and new points constructed directly from given points.

THEREFORE, the possibility or impossibility of a desired construction depends upon whether or not the essential new points involved can be constructed from the given points as intersections of straight lines and circles. This leads to the subject of constructable points.

Before proceeding to an important theorem, let us recall to mind the implications of the word "rational," as used in mathematics. First, we remember that the arithmetical processes of addition, subtraction, multiplication, and division are called the rational operations, whereas the operations requiring the use of the radical sign ($\sqrt{}$) are termed irrational operations. Consequently a quantity is said to be a rational function of some other quantities if it can be expressed in terms of these latter by means of the rational operations alone, that is, without radical signs. Likewise, the roots of an

(*Please turn to page* 228)

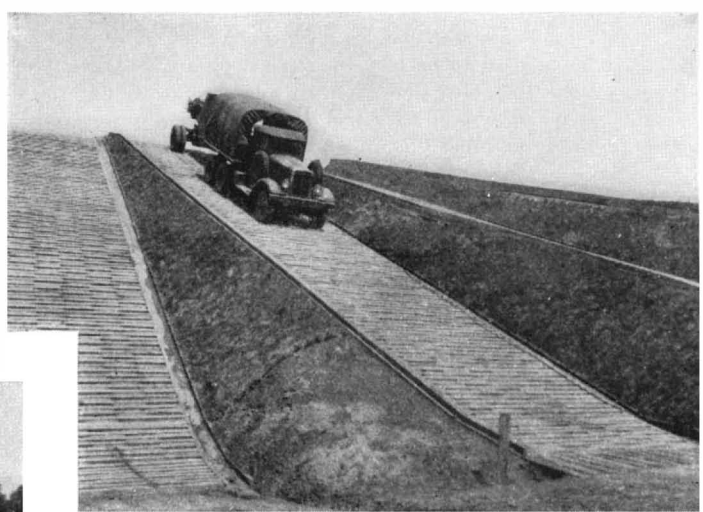
CAN THEY

To see a 75-mm gun carriage go bouncing down the cross-country course, towed by a prime mover at high speed, is to marvel at the strength built into it

MANUFACTURERS of motor vehicles maintain such elaborate proving grounds that the layman is likely to think that the tests conducted thereon are sufficient to indicate a vehicle's ability to perform satisfactorily under most known conditions. This is fallacious reasoning. The ability to negotiate hills, curves, and mud, sand, and water holes on a commercial proving ground do not mean that a vehicle will stand gruelling military service. The military engineer, moreover, is interested not alone in the ability of any mechanism but also in its capability.

At the Aberdeen Proving Ground, Maryland, the Ordnance Department of the United States Army tests all types of ordnance equipment, tries out new weapons to overcome defects, tests and retests in order that only equipment which is as perfect as man can make it will be adopted for service. Their duty, in these days of rapidly increasing mechanization and motorization of the Army, includes thorough investigation of all Army vehicles. "It is the aim of the Proving Ground," says Lieutenant-Colonel G. M. Barnes, writing in *Army Ordnance*, to whom we are indebted for these illustrations, "so thoroughly to conduct automotive tests that any vehicle, whether of Ordnance Department or commercial design, receiving the approval of the Proving Ground may be

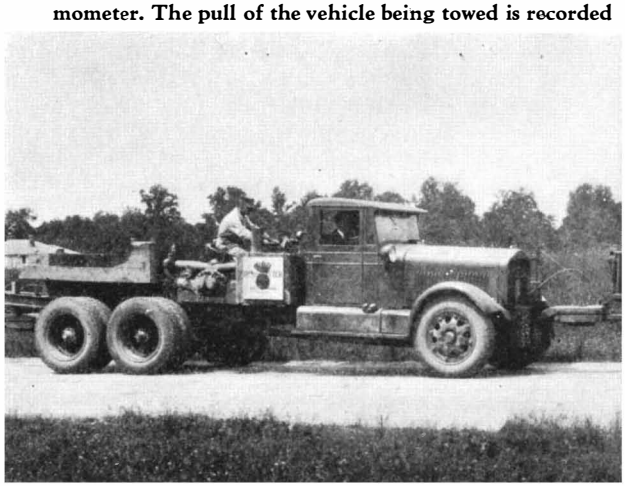
A medium tank, of the high-speed type, climbs a three-foot vertical wall, putting great strain on its track



The brakes were good, for they stopped this truck when it was towing a three-inch-gun mount down the slope course

This light truck is not an amphibian, yet it carries "a bone in its teeth" as it tows a gun-carriage through the concrete water course—an extreme hazard

The resistance to traction, of a vehicle, is found by mometer. The pull of the vehicle being towed is recorded



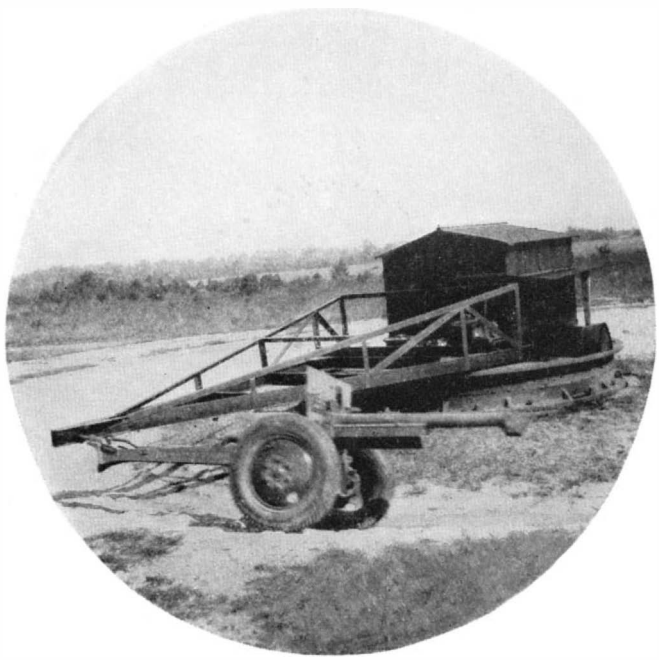
Take It?

expected to give reliable service when issued to the combat arms of the Army."

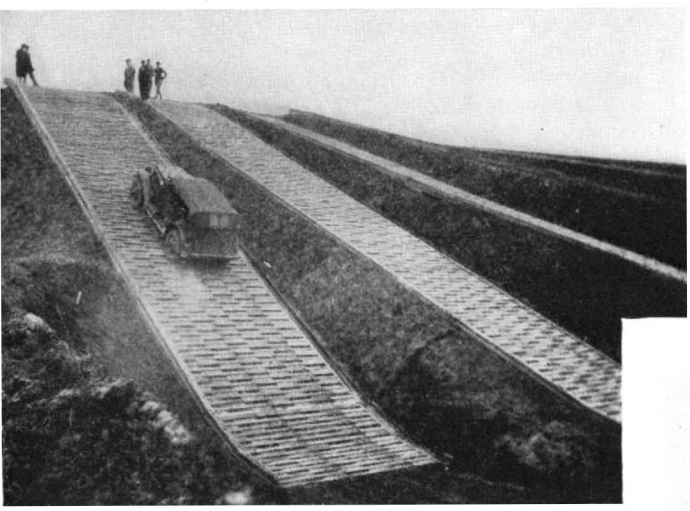
As most cross-country fighting vehicles are of the track-laying type, the Ordnance Department is primarily concerned with this general class. Wheeled vehicles, however, are also important, as this type is used in scouting, reconnaissance, and sometimes even for fighting where terrain is favorable. All types, in modern warfare, must be able to "take it."

At Aberdeen Proving Ground, laboratory tests provide engineering data on automotive components, while field tests determine the capabilities of the complete vehicle under field conditions. After data on engine horsepower, transmission losses, efficiency of parts and of the complete vehicle, are obtained, then come the more spectacular, outdoor tests. Draw-bar pull and draw-bar horsepower, power losses, resistance to traction, and other characteristics of vehicles are obtained by use of a field dynamometer. The accelerometer for recording time and distance traveled, is another valuable instrument used. The photographs show some of the more obvious tests, with various types of vehicles passing through the water and mud courses, over the cross-country course at high speed, up and down the slope course. The sand course and the concrete washboard course (not shown) also supply valuable data.

Track-laying units balk not at mud, though handicapped with wheels in front as was the case with this half-truck car in the soupy mud of the mud course



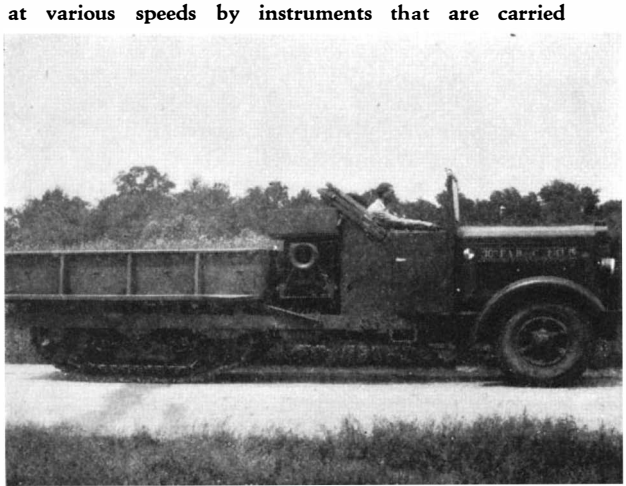
Severe punishment: a 75-mm gun carriage being whirled on the merry-go-round of the circular cobble-stone course



Scout cars must be tough—and powerful. This one climbed a 60 percent grade, the steepest on the slope course

Proving that a depth of 18 inches of mud is no fit highway for a truck. This powerful military truck stuck tight in the mud course at that depth

attaching the vehicle to the rear draw-bar of the dyna- at various speeds by instruments that are carried



AMATEUR SEISMOLOGY

Half Amateur, Half Professional . . . Constant Battle . . . Listing the Difficulties . . . No Royal Road to this Scientific Hobby . . . Work . . . Work

By ALBERT G. INGALLS

A RELATIVELY new field for the demi-scientist or half amateur, half professional, is earthquake recording—amateur seismology[1]. Now that engineers, architects and insurance men have found that it will pay in dollars and cents and human lives to build up an applied earthquake science, and not leave seismology entirely to the purely theoretical or pure scientist, the need of establishing stations all over the earth, in order to learn just how the earth shakes, has become evident. Seismology is still a young science.

In November, 1929, this magazine published an article entitled "Amateur Seismology" and in it a small seismographic instrument was described. That instrument was designed for recording local, rather than distant, world-wide shocks, yet quite a number of our readers made copies of it, and among these was Mrs. M. M. Seeburger of Des Moines, Iowa, whose photograph is shown on the opposite page. "But," Mrs. Seeburger writes, "because of its impracticability in a non-seismic area such as Iowa, I soon abandoned it in favor of teleseismic instruments." Teleseismic instruments are seismographs which record distant earthquakes.

RECENTLY, Mrs. Seeburger was invited to write an article about her present equipment and station, called "the Des Moines Seismological Station," but she felt that her connection with seismology had not been long enough to justify her writing a signed article about it. However, the present writer, also being interested in seismology, thereupon asked Mrs. Seeburger a number of written questions, and the replies to these questions constitute a sort of interview which is in many ways more readable than a formal article would be. Mrs. Seeburger writes:

"I am pleased to know that you are interested in the construction of the instruments used in the Des Moines Seismological Station. Their development has been a task full of problems, and also thrills. Constructing an instrument is a good apprenticeship for any one adopting seismology as a vocation or an avocation. There is seldom a repair man just around the corner when a seismograph gets temperamental and it is necessary to know your instrument from the ground up, or rather from under the ground up. I am still learning about mine and discovering new ways to improve it.

"MY instruments are modified Bosch-Omori in type, with both components (north-south and east-west) recording on one drum. Each component consists of a horizontal pendulum pivoted on an upright set in a reinforced concrete pier which extends three feet below the floor of the basement seismograph room. The upper suspension consists of fine piano wire attached to bolts in each side of the heavy mass, and extending from the top of the upright. The heavy mass, a 24 kilogram lead cylinder, is adjustable along the boom of the pendulum, which is made of ⅜-inch pipe. The wire suspension at the top of the upright is adjustable from right to left by means of a screw, so that the position of the pendulum may be shifted to correct the tilt which accumulates with temperature changes. The angle of the top suspension can also be adjusted to regulate the period of the pendulum, which in my instruments is nine seconds; that is, a complete free and undamped swing of the pendulum requires nine seconds.

"The customary lever magnification system has been abandoned in these instruments in favor of a silk thread and spindle device, which reduces friction but requires a great deal of attention and a very delicate touch to keep in perfect adjustment. A steel rod, attached to the end of the boom by a three-way adjusting device, ends in a U-shaped fork, having a needle eye at the end of each tine. The fork moves in the same plane as a clock wheel, mounted on a pinion, working in jeweled bearings in a frame, the wheel being between the points of the U. A groove is cut in the rim of the wheel and a fine silk thread connects the two needle eyes, passing once around the groove in the wheel. The thread must be kept at unvarying tension and operating in the exact plane of the wheel, else sensitivity is lost. Riveted to the wheel is a recording arm of very light aluminum, ending in a fork with a very light arbor set in polished bearings. The arbor carries a balanced stylus which has just enough weight to remain on the smoked paper. The Des Moines instruments magnify the earth movement 15 times.

"THE drum, 13 inches long and 8½ inches in diameter, is turned by a power clock by means of a sliding clutch device, with a lead screw at the opposite end of the drum from the clock. The drum makes one revolution per hour. The drum is mounted on a reinforced concrete pier three feet in depth. Smoked paper is used on the drum, the stylus marking its record on the smoked paper as the drum revolves. Both components record on the same drum, one pendulum being parallel to and one at right angles to the drum.

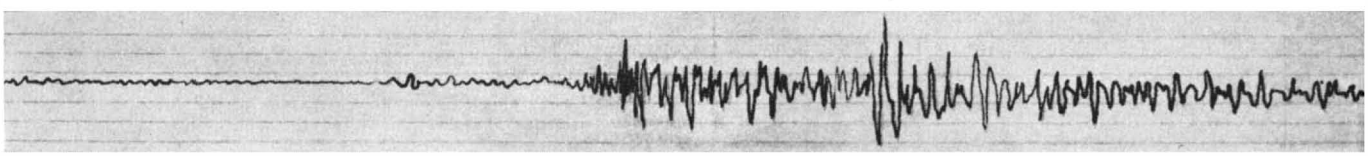
"Time control is provided by a very good regulator clock, which closes an electric circuit every minute, operating an electro-magnet over the drum, lifting the styli for three seconds, leaving a gap in the record from which time can be computed.

"An oil damping device prevents the pendulums from continuing their swings and complicating the record."

Interesting as was the above communication, it did not cover some questions which the readers of this magazine

[1]The correct pronunciation is sis-mology; "sis" rhyming with ice. Often mispronounced.

A seismogram from one of Mrs. Seeburger's first recorded

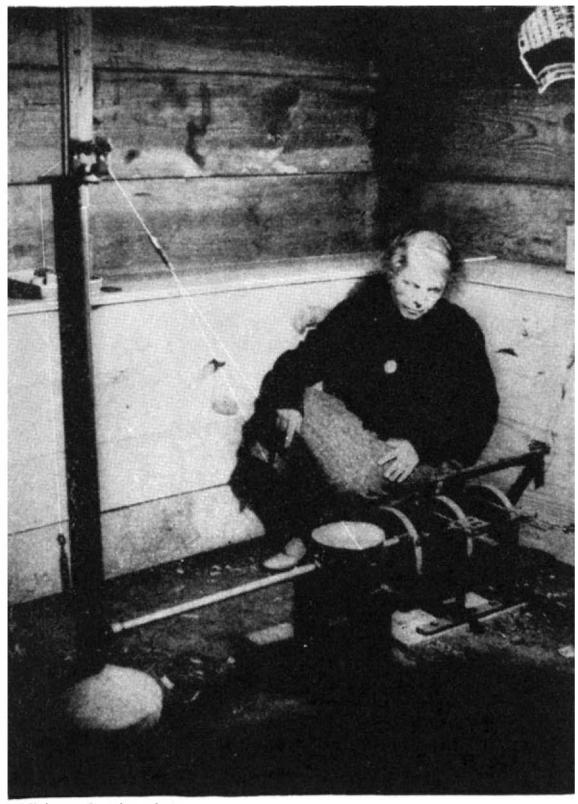


might be likely to ask. Therefore the next letter to Mrs. Seeburger asked the following questions: "What did the entire equipment cost to make? What special difficulties, if any, did you experience, and what results did you get from the seismograph? Can you, for example, record the distant quakes mentioned daily in the newspapers —those in Japan, South America and so on? How did you get your design? How would a reader go about getting a start as an amateur seismologist? Have you a scrap of record made on this particular seismograph which you can spare, for reproduction?"

Mrs. Seeburger's reply:

"Your letter finally caught up with me in Iowa, after pursuing me throughout the west for several weeks. Now for your questions.

"I did not keep a record of the cost of my instruments and station equipment. It did not exceed 150 dollars, but I could not duplicate it for that, so that figure might be rather misleading. The most expensive items are the power clock for driving the recording drum and the regulator clock which governs the time marks on the grams. These I bought at a bargain from a bankrupt jeweler, else my expense would have been more. I did my own cement and foundry work, but employed a machinist and also a watch maker for work on some parts of the mechanism.



Science Service photo

Mrs. Seeburger of Des Moines with the seismograph she designed and built, and which she operates

"LISTING the difficulties would fill your magazine. Reducing friction to a minimum in every adjustment and bearing, yet without allowing any lost motion, is a constant battle. A movement of the earth amounting to .01 to .001 millimeter must be recorded, and this is impossible unless every bearing is kept perfectly polished, every adjustment perfectly made, and the whole magnifying and recording system so lightly made and delicately balanced that even the tip-toe step of a tiny child inside the doorway of the seismograph room causes the needles to quiver.

"I had a great deal of trouble working out electric circuits to record minute marks on my grams. A circuit must be closed every minute, operating a magnet which lifts the needles for four seconds, thus leaving a gap on the record. The problem was to devise an electric circuit strong enough to lift the needles, but not strong enough to stop the clock on the contact, and using contacts of a material that would not readily burn out. My contacts are of platinum-iridium, and a 1½-volt dry cell is used for power.

"Then the seismograph room had to be specially equipped for keeping the temperature uniform. These are just a few of the many problems.

"Results have been very satisfactory for low-magnification instruments. I recorded the Quetta, India, shock, more than 10,000 miles away, also one in North Africa, last spring, as well as closer ones in the Aleutians, Mexico and various parts of the United States. I enclose a blue print of one of the first earthquakes I recorded. It originated in Lower California, distance, approximately 1400 miles.

"However, no stations, even those with the most expensive and intricate instruments, record daily quakes, except perhaps in highly seismic localities where there are occasional series of local shocks. Of teleseismic records the best one can hope for is two or three shocks per month. Often there is only one. For this reason, as well as because of the expense of installation and upkeep and the large amount of time required daily to keep the instruments in successful operation, I doubt whether teleseismic instruments will ever be popular with amateurs.

"The amateur astronomer can study the stars two or three or four nights a week, when it is most convenient, but the seismologist must be on the job every day and every night, changing records, figuring shocks when any occur, and 'trouble shooting.' He is as bad off as a young mother nursing a pair of twins.

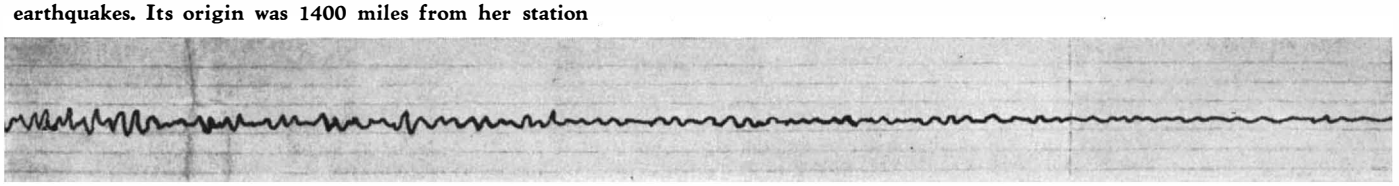
"LEARNING to interpret the records of distant shocks is also an intricate study. I tear out another handful of hair every time I try to compute the distance of a new type of shock—afraid I will disgrace myself by reporting a shock several thousand miles from where it happened. Of course the exact location can only be determined at some headquarters receiving reports from a number of stations; for example, the United States Coast and Geodetic Survey or the Jesuit Seismological Association. A single station can only determine distance and sometimes direction.

"How did I get my design? I visited most of the stations in the western half of the United States. Then I read all the nice (?) easy literature you mentioned, and some German books in addition. It all went over my head, and I had to back up and start over. I still re-read that literature every six months, and each time manage to absorb some new facts. Eventually I decided on a Bosch-Omori type as the simplest for a beginner, and grafted thereon a number of ideas from other instruments—experimented and discarded and experimented some more—filled a ton or so of paper with computations on friction and damping. Dr. Neumann, Chief of the Division of Seismology of Geodetic Survey, to whom all my reports are sent, has given me much helpful advice.

"The instruments I use are designed for teleseismic recording, that is, the recording of distant shocks. A strong local shock would dismantle them.

"I think any of the seismologists are glad to encourage amateurs in the field, provided they will put in the time, money, study and continuous work necessary to establish and maintain accurate and dependable stations."

earthquakes. Its origin was 1400 miles from her station

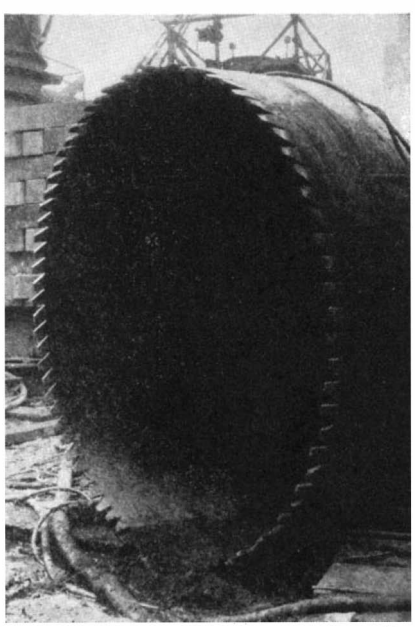


New Caissons Speed Work

By R. G. SKERRETT

"GYRATING" caissons are the latest aids to the foundation engineer in providing proper support for massive buildings where a satisfactory footing can be reached only many feet below the ground surface.

Caisson sinking is necessarily a more or less protracted operation, depending upon the nature of the ground penetrated and the depth to be reached; "sand hogs" are paid high wages because of the hazards of their occupation. To effect economies and to do the necessary work quickly, gyrating caissons of large diameter and of an average length of 60-odd feet have been utilized recently to provide the essential underpinning for the new Federal Office Building in New York City, which is to occupy an entire city block. To give it suitable support, the contractor was called upon to construct an underpinning, reaching to bedrock, and made up of no fewer than 112 separate concrete columns or a corresponding number of groups of steel and concrete piles. Preliminary borings, made at different points of the site, disclosed the presence of boulders that would obstruct the driving of piles. The bedrock slopes and has an uneven surface, and it lies from 65 feet to 70 feet underground. For 50 feet down, the ground is sand, followed by layers of clay, gravel, hardpan, and a bottom stratum of quicksand just above the rock. Boulders up to several feet thick are embedded in the deeper layers of the formation.

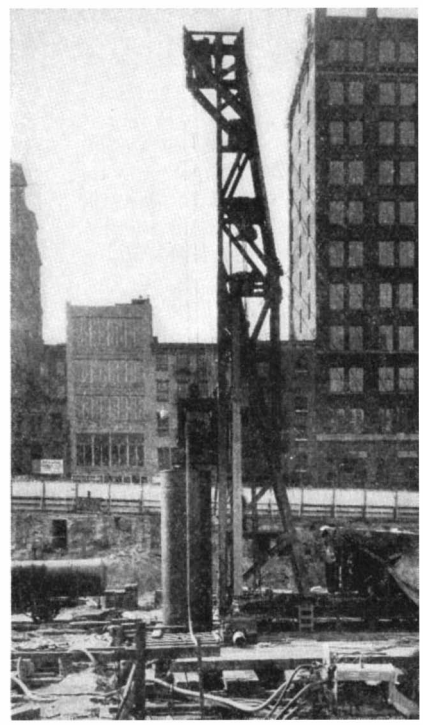


Tungsten-carbide coated teeth on the caissons resist the great wear

The caissons were steel tubes from 4 to 8½ feet in diameter, with walls ⅜ inch or ½ inch in thickness, and the cylinders averaged 66 feet in length. The cutting edge, in each case, was a ring of heavier steel that carried great teeth arranged like a rip-saw, and those surfaces of the teeth most exposed to wear were made more resistant to the abrasive action of the ground by coating them with a film of tungsten-carbide. When stood upright for sinking, the top of the caisson was sealed with a headplate through which passed one or two connections for a corresponding number of water jets that had their outlets a short way above the cutting edge. During sinking, each caisson was guided by a head frame 78 feet tall; at the front of that tower there was a car on which was mounted a horizontal gear wheel driven by an electric motor of more than 100 horsepower. The gear wheel could be turned at a rate of from 4 to 11 revolutions a minute, and this rotating mechanism could be locked to the headplate of the caisson so as to spin the latter. The car carrying the rotating apparatus was suspended like an elevator, and was raised or lowered by an electric hoist placed upon the platform at the rear of the tower.

WHEN a caisson was lifted upright and set in position for sinking, the dead weight of the caisson forced its cutting edge into the ground and sealed that end of the cylinder. With that done, the caisson was partly filled with water by its jet or jets, and then the rotating machinery was started. As the saw-like teeth cut their way downward, water was discharged continually by the jets so as to over-balance the pressure of ground water and to maintain a continuous outward and upward flow of water from the caisson. Fully 70 percent of the material that entered a caisson was disposed of in that way. The water jets operated at a pressure of 100 pounds per square inch.

The majority of the caissons were driven to bedrock and deep enough into the ledge to seal them there so that their headplates could be removed and the gravel, hardpan, and pieces of rock remaining could be lifted out with grab buckets. In some of the caissons, where



A caisson part way down, showing the car and one of the water lines

the irregular surface of the bedrock or its slope interfered with the complete sealing of the cutting edge when rock was reached, the cylinders were equipped with air locks, put under pressure, and "sand-hogs" then went down into them to clear away the remaining material preparatory to placing a concrete seal. The concrete seal shut out ground water and formed the first bond between the bottom of the caisson and the supporting rock. Subsequently, those caissons, as well as all the others, were filled to their tops with concrete, and on those solid columns or piers was laid the foundation for the walls of the great structure.

To sink pneumatic caissons of the same dimensions in ground of a similar nature, to corresponding depths, would have required, so it is said, anywhere from six to eight days for each caisson. The gyrating caissons made their journeys downward at speeds varying from 12 feet to 20 feet an hour, depending upon the resistance offered by the ground and the size of the caisson. Even the presence of ground water, reached almost at the very start of the operations, due to the proximity of the site to the original Hudson River shore line, did not slow up the sinking of these newly developed aids to the construction engineer.

Energy from the Sun

Step by Step Solar Engines Increase in Efficiency ... May Reach Economical Level as a Power Source

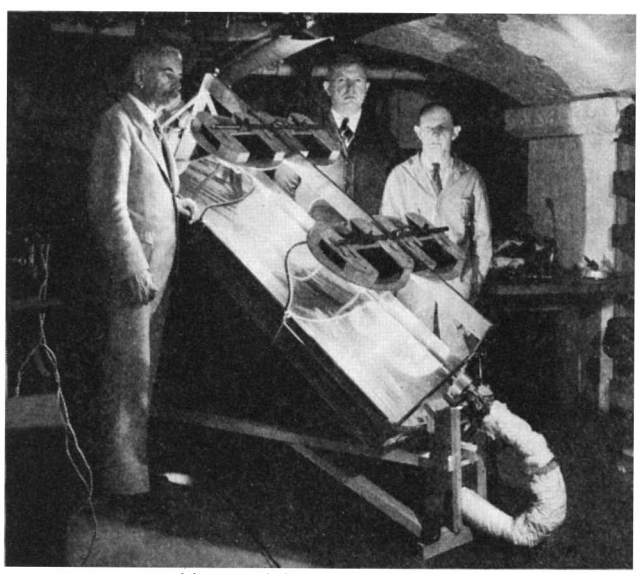
IN the June number, 1935, we published a photograph of the improved solar cooker developed by the head of the Smithsonian Institution, Dr. C. G. Abbot. Since that time Dr. Abbot has once more changed the design and raised the efficiency of his solar heat concentrator, and there is now some actual promise that, with a few more such increases, solar heat, as an ordinary power source, may enter the market in competition with the one source of energy which we now find most generally efficient, all things considered; that is, coal.

Dr. C. G. Abbot has made various experiments in the last 20 years as a contribution to the age-long problem of using solar heating for power, cooking, and other purposes. His studies have culminated in an efficient machine.

The energy of the sun's rays which would fall at sea level on a cloudless day on a square yard of surface at right angles to the rays, turned completely into mechanical work, would slightly exceed one horsepower. But many losses occur. Of these the greatest single one results from Carnot's theory of the perfect heat engine. It is shown that the greater the range of temperatures employed, the greater the efficiency. Hence the effort has generally been to reduce heat losses and concentrate solar rays, so as to raise a very high working temperature in the solar engine.

BUT this hitherto has involved large and costly heat collectors and associated apparatus. Though solar rays cost nothing and are available to at least 1000 times our total present consumption of coal, oil, and hydroelectric power for all manufacturing, heating, and lighting requirements, solar power has hitherto been unable to compete economically with these other sources.

Dr. Abbot's improvements lie first in the cheap yet accurate and efficient ray-collector employed, and second in the highly efficient and heat-saving absorber for the collected rays. He employs a parabolic cylindrical mirror of Alcoa sheet. This comes in large sizes as a flat, thin sheet of very light specific gravity, reflecting over 80 percent of solar rays, and so permanent in surface that a year's exposure to the weather produces no appreciable deterioration. A simple metallic framework of aluminum and duralumin makes up a cradle of the exact parabolic curvature required. He prefers the curve whose equation is $y^2=30x$. To this frame the metal sheet may be screwed down without previous forming. Experiment shows that the present unit mirror with a two-foot wide sheet about six feet long will bring the sun rays to a focal line no wider than a lead pencil.



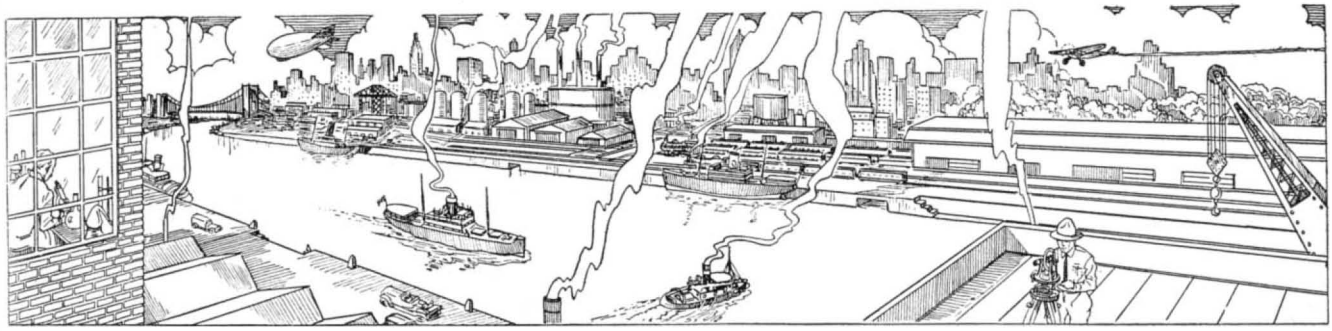
Dr. C. G. Abbot and his latest sun's ray collector, a more efficient energy source than any previous model

At the focus the rays pass through two concentric tubes of Pyrex glass 1¼ inches and ⅞ inch in diameter respectively, till they reach a central ½-inch Pyrex tube, metal plated on the top third of its circumference, and within which flows a black liquid called Aroclor. This liquid is a chlorinated diphenyl compound made by the Monsanto Chemical Co. With the addition of a very little lampblack it almost totally absorbs the focused solar rays, and though still liquid when reduced to ordinary temperatures, it does not boil or flash at 350 degrees, Centigrade (662 degrees, Fahrenheit). A high vacuum is maintained between the tubes so that heat is lost only by radiation, as in a Thermos bottle.

A flow of the liquid is maintained either by gravity circulation or by a pump. Thus the heat absorbed from sun rays is carried away to the apparatus for steam power (such as a tubular boiler), for cooking (such as a reservoir with inserted ovens), or for evaporating liquids (such as an open coil).

Experiments and theory agree in promising an over-all efficiency of 15 percent for steam power production. This contemplates a boiler at 382 degrees, Fahrenheit, so that its maximum theoretical thermodynamic efficiency is about 40 percent. Losses by reflections, inefficiency of steam engine and so on, bring the final figure to 15 percent. This is a very substantial improvement on previous sun motors. Ackermann, in "Utilization of Solar Energy" (Smithsonian Annual Report, 1915), claims 183 square feet per brake horsepower as the best output of the solar power station of "Eastern Sun Power Ltd." near Cairo, Egypt, in 1913. It is computed that with equal sun intensity the Abbot machine will require but 60 square feet per horsepower. Ackermann goes on to claim practical equality in economy with coal at £3 10s per ton. If so, the present machine could compete with coal at £1 3s per ton, if the relative costs of the machines are equal. But here again there is a marked saving in the greater simplicity of present construction.

A half-horsepower steam-raising model is in construction. Whether a substantial proportion of the world's power demands will be taken on by sun power within a few years is doubtful, but it is believed that if it were required, the power field might be filled by sun power at little if any advance in costs with present appliances. This would, of course, require co-operating storage of power. The most obvious, though very costly, method is through the storage battery. Another is by pumping water to a reservoir on an adjacent hill or mountain and recovering power from its fall. A third is by chemical synthesis of active agents, as by the decomposition of water. A fourth has been suggested in which heat itself is economically stored.



THE SCIENTIFIC AMERICAN DIGEST

Conducted by F. D. McHUGH

Contributing Editors

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Treasure

SOME time ago we published a discussion of the Metallascope, a so-called treasure finder operating on well known radio principles. This instrument is fully portable, weighing only 22 pounds, and is easily carried by an operator over ground

The "treasure finder" in use

which is being investigated for hidden bodies of metals, either in the ore or bullion state. It is interesting to note, according to a recent letter from Mr. Gerhard R. Fisher, who developed the instrument, that a few months ago a large amount of gold, silver, and copper, said to be valued at 14,000 dollars, was found with one of his instruments at the Tumacacori mission in Arizona.

Still a Puzzle

TEETH may decay in spite of a completely adequate diet, it is shown by experiments at the College of Physicians and Surgeons of Columbia University. Tests lasting three years contradict the theory, widely held in both scientific and lay circles, that tooth decay is caused by a dietary deficiency.

"The practical significance of this finding is that, while we know it is possible to reduce the amount of caries or dental decay by improving the diet, we now know that we cannot prevent decay completely by this method," said Dr. Theodor Rosebury, assistant professor of bacteriology, who conducted the research. "The reason for this is that a deficient diet is a modifying influence rather than the primary cause of caries, which still remains virtually unknown."

Dr. Rosebury fed five generations of rats "a fully adequate diet." Over a period of three years, the rats continually developed caries. "This result," he explained, "checks with human experience to the extent that we know the disease occurs in human beings healthy in all other respects and giving evidence of adequate nutrition. We can produce caries more rapidly with diets deficient in mineral elements. But no matter how adequate we make the diet, dental caries is still produced."

FIVE MILES—ONE POUND

A PIECE of nickel tubing has been produced with an outside diameter of .005 of an inch and a wall thickness of .0008 of an inch. Each linear foot of this tube weighs .000046 of a pound and it would take more than five miles of it to weigh one pound.

Gasoline Prices

WHILE a great many technical improvements have been made recently in the manufacture of gasoline, the motorist continues to pay about the same price for his fuel. As R. S. McBride, writing in *Chemical and Metallurgical Engineering*, points out, this is due to economic conditions over which the technical man has no control. The objective of the gasoline maker is to put a high-grade motor fuel into the motor-car tank at the lowest feasible cost for material, labor, capital charge, and distribution expense. Unfortunately, the greatest attention on the part of the public is directed toward the second or third of these items, which are the smallest in actual importance to the motorist when he buys his gasoline. There is a great commotion over new processing methods; and there is quite a hubbub from time to time about competing materials. However, the chemical engineer processes all the raw materials so efficiently that the labor and capital charge involved are probably less than a quarter of the average tax paid to states on each retail sale. Hence in today's retail price, tax is the biggest factor, distribution expense is second, raw material cost is third, and the processing expense is a poor fourth in the price burden on the motorist. Improvements in processing will come, but they cannot revolutionize the pump price of the gasoline.—*A. E. B.*

Telescope Glass for Cooking

ASTRONOMY and cooking marched hand in hand during the three years' research which led to the development of the ultra-low expansion type of glass that was used in the great 200-inch diameter disk of glass for the new telescope of California Institute of Technology.

An item from *Science Service* states that astronomy obtained the disk for the telescope mirror out of investigations in which 1500 different kinds of glass were studied.

A glass dish with removable handle to be used for top-of-stove cooking

Housewives will benefit from the same work, for one of the new glasses is now being used for a new type top-of-the-stove glass cooking utensil.

The new style glassware has a still lower coefficient of expansion than the well-known oven glassware already manufactured by the Corning Glass Works. The new glass, which can be placed right over a flame on the stove, is designed to supplement rather than replace the present oven-type glassware.

What makes ordinary glass crack when heated suddenly or unevenly, indicates Dr. J. C. Hostetter, who had charge of making the great telescope disk, is the large coefficient of expansion which sets up unequal stresses that finally pull the glass apart.

For glassware used directly over a flame, the minimum coefficient of expansion is a desirable characteristic, but it must be coupled with other factors such as mechanical strength and length of useful life.

For the great telescope mirror disk, low expansion was also a major requirement. Thus the search for the proper glass had the two objectives, with astronomers and the housewife jointly benefiting.

44^2

THE title of this note is simply another way of writing the year 1936, for this number is an exact square of 44. This is the first time since 1849 that the year has resulted from a perfect square, and it will not happen again until 2025 A.D.

Diagnostician for Automobile Ills

IN the same manner that a physician uses his instruments to check the functioning of a human body, an automobile mechanic may quickly and accurately determine the condition of a motor through the use of the Ford laboratory test set.

The battery is the first object of investigation where a complete inspection is made. Strength of the individual cells is recorded on a three-volt meter. The same meter is used to show a defective ground strap or loose ground connection. Leads are connected at each side of the ground connection and resistance set up by a poor connection shunts the battery current through the three-volt meter. Thus a low reading means good conductivity and a high reading, poor connection.

Cable and cable connections from battery to starter switch are checked in the same way, by cutting in a 15-volt meter. After all starter connections are checked, a test of the starter motor is made to determine its amperage draw.

Instruments that find car troubles

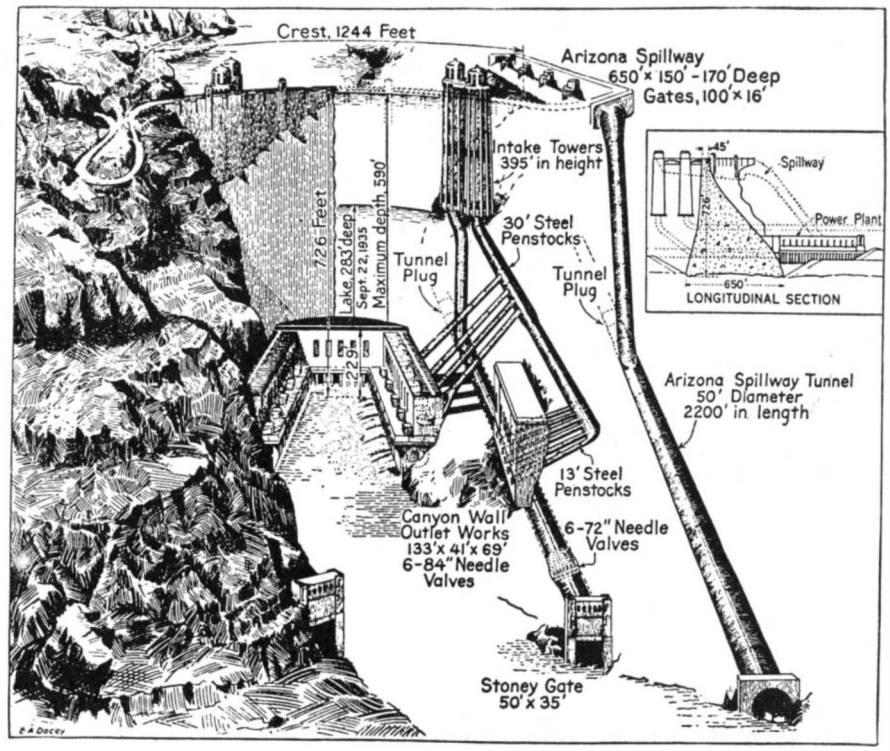
This test will show low battery voltage at the starter, poor brush contact on the commutator of the starter, a shorted armature, bent shaft or tight bearings. The test is made by connecting a high-reading ammeter to the hot and cold sides of the starter switch and noting the readings, while the engine is running.

The compression test, made by recording the pressure in any cylinder on the compression gage, will reveal defective piston rings, defective valves, or gasket leaks. Normal compression on the gage shows everything is all right. Low compression, when brought up to normal by oil sealing the pistons, shows loss of compression past the piston rings. Low compression not brought up to normal by oil sealing the pistons shows valves are in poor condition or gaskets leaky.

Examination of the primary ignition circuit includes tests for freedom from shorts, condition and spacing of distributor points and breaker arm spring tension.

The secondary ignition circuit is tested by spark gaps which are adjusted to the engine compression reading. Provision is also made for testing the condenser.

Proper fuel flow is checked by testing both the fuel pump vacuum and pressure. The test set not only checks the carbureter but furnishes a means for quickly making a correct adjustment. The generator is checked for condition, charging rate, and output voltage.



A partial section of Boulder Dam. See description below

Schematic of Boulder Dam

HOW does Boulder Dam work?

This question has been asked innumerable times. In an effort to explain the workings of the dam the accompanying drawing, with the Nevada wall of Black Canyon remaining solid, and the Arizona wall cut away to reveal the intake towers, the spillway, the penstock pipe, and outlet works, has been made by E. A. Dacey, chief draftsman of the Bureau of Reclamation staff.

For the convenience of readers the dimensions of the dam and its appurtenant works are given on the drawing.

A small longitudinal section has been inset on the drawing for the purpose of showing the thickness of the dam at its base and at its crest. This inset also will illustrate the relative position of the intake towers and the spillway to the power house and dam.

Inside the Nevada wall of the canyon a similar set of penstock, diversion, and spillway pipes has been placed.

It will be noted that all the diversion tunnels, constructed to carry the water of the river past the dam site during the construction period, have been used for at least a part of their length in the permanent construction. The two spillways lead by a sloping incline into the two outside diversion tunnels, which have been plugged upstream from the juncture. One of the penstock pipes on each side is carried for the major part of its length through the inside diversion tunnels, which also have been plugged.

The penstocks, it will be noticed, feed the turbines in the powerhouses through branch pipes, and continue down stream to outlet works emptying directly into the canyon below the dam.

The spillways are safety valves. They have a combined capacity of 400,000 second-feet. It is not probable that they ever will be used, but they stand ready in case of emergency. The largest recorded flood on the Colorado reached a maximum of approximately 250,000 second-feet. However, before records were kept a flood which may have reached a height of 300,000 second-feet occurred. Should even this latter flood pour into the reservoir when it is brim full, it would not tax the spillways or use more than three

quarters of their capacity. It is not contemplated that during flood seasons the reservoir will be allowed to remain brim full. The big floods on the Colorado always occur in the spring when snow begins to melt in the mountains, and they can be foreseen. However, as an added precaution, the penstocks themselves can be used in time of emergency to dump an additional 100,000 second-feet of water past the dam.

Thus, a total capacity of 500,000 second-feet is provided in the spillways and penstocks, a capacity twice the greatest recorded flood.

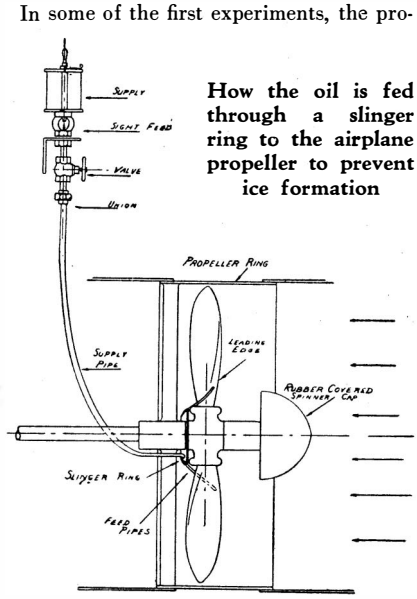
MAPS

DESPITE the fact that people are now more map-conscious than ever before, not more than 47 percent of the United States has been completely mapped to show elevations and slopes. In this respect, Dr. William Bowie of the Coast and Geodetic Survey says that the United States is one of the most backward of all the highly organized countries of the world.

DE-ICING THE PROPELLER

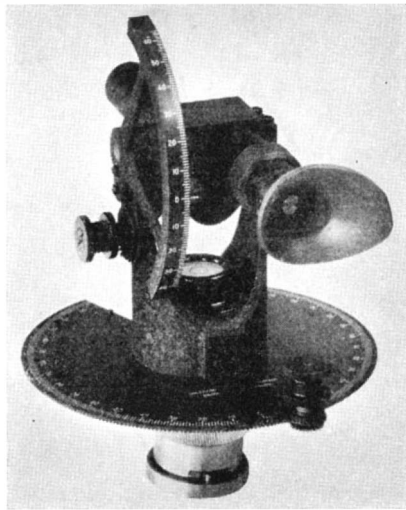
AS our regular readers already know, the Goodrich company has been responsible for the development of airplane wing de-icers, sometimes known as "overshoes," which have added much to the safety of flying. The ice hazards of flying, however, were not entirely eliminated thereby; there still remained the problem of de-icing the propeller.

In some of the first experiments, the propeller spinner was covered with rubber to break the continuity of ice across the hub, and oil-saturated rubber was applied to those portions of the blade on which ice formation was likely to occur. The de-icing oil minimized the adhesion of the ice to the propeller and allowed centrifugal force to throw it off in small particles. With the advent of geared engines and slower speed propellers, however, these precautions no longer sufficed.



How the oil is fed through a slinger ring to the airplane propeller to prevent ice formation

Now, with the co-operation of the Bureau of Air Commerce, and T. W. A. Airlines, the Goodrich company has developed a system



Drift and speed indicator

of continuously feeding a de-icing compound to the revolving blades; the experiments have been so successful that 60 "de-icing slingers," as they are termed, are to be installed on twin-engined Douglas airplanes employed by Transcontinental and Western Air.

Modern engineers and chemists no longer proceed by "cut-and-try" methods on actual full scale machines or equipment, but use laboratory methods first. Accordingly, a special refrigerated wind tunnel was employed in the initial experiments. The tunnel was surrounded with a refrigerated chamber and water spray was injected into the air-stream. A 2000-watt spotlight threw a beam to a mirror which was revolved by an electric motor. In the viewing mirror the propeller blades appeared to be at rest when the speeds of the revolving mirror and of the propeller were synchronized, and could be carefully observed.

The de-icing slinger is illustrated in one of our diagrams. From the de-icing fluid supply tank, a regulated feed system permits the fluid to flow through the supply pipe to the slinger ring. The fluid falls under gravity on a circular piece of felt which is kept taut by a circular coil spring. The fluid passes through the felt to the feed pipe which brings the fluid in contact with the leading edge of the propeller. Of course the supply pipe is stationary. The slinger ring, spring, feed pipe, and so on, revolve with the propeller.

Two main lines of attack have been followed. In one the propeller blades were covered with rubber and supplied with oil. In the second a mixture of alcohol and glycerine was fed to the bare aluminum blades.

While the first plan has the advantage that the blades continue to de-ice as long as the rubber retains any oil, there is too much labor in applying the rubber and the aerodynamic efficiency of the propeller is somewhat impaired.

With the second system, greater simplicity of installation is obtained and there is instantaneous shedding of the ice. The sole disadvantage is that de-icing stops immediately when the supply of oil ceases. It is the second system which has been adopted for use on the airlines.—*A. K.*

A CONVENIENT DRIFT AND SPEED INDICATOR

THE air-speed of an airplane is readily determined by the ordinary air-speed indicator, which is actuated by the pressure developed in the Pitot tube. But the air-speed is *not* the true speed over ground or sea, because it takes no cognizance of the wind speed. In flying over the ground, corrections may be made by sighting on landmarks, but in flying over sea the problem is more difficult. An artificial reference mark must be created by means of a smoke signal or bomb thrown into the sea. Then there must be available an easy method of sighting on the smoke signal.

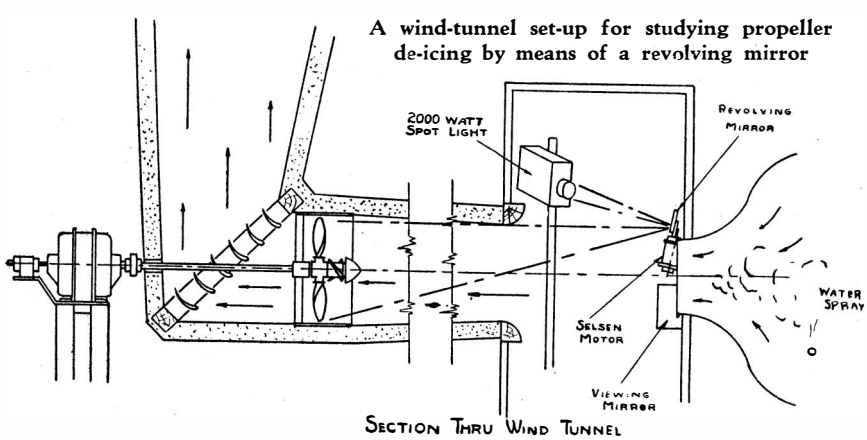
Pan-American Airways, whose operations are mainly over sea, has long made use of such smoke signals. The instrument used in conjunction with this signal is called a drift and speed indicator, and has appeared in many forms. The most modern, and one of the most useful of such drift and speed indicators, is that developed by the Kolsmann Instrument Company and illustrated in our photograph.

The drift sight consists of a telescope, supported by two standards, mounted for rotation about a vertical axis for measuring horizontal angles. These angles are determined by an index fastened to the standards and riding against a scale divided in degrees. The telescope can also be rotated about a transverse axis. Its elevation or depression is measured on the vertical arc.

The instrument is supported on a ball and socket joint and is leveled by a spirit level mounted in the center of the standards. The ball and socket joint terminates in a cylindrical shank which is fitted into a mounting bracket suitably disposed on the aircraft.

In fixing the sight into position, it is very important that the telescope should point exactly fore and aft when the index of the horizontal graduation is at zero. To achieve

A wind-tunnel set-up for studying propeller de-icing by means of a revolving mirror



this condition, a distant reference point is selected, and the airplane is turned into the direction of such point by sighting along the line defined by the rudder post and the propeller hub. Then the telescope is turned till the horizontal graduation reads zero. Only then is the drift sight fastened rigidly in place to the mounting bracket.

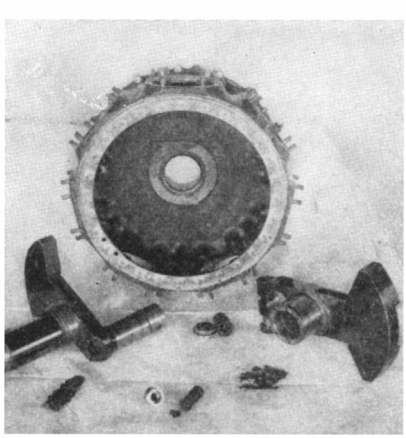
To determine the angle of drift or lateral motion of the airplane away from its fore and aft axis is quite simple. A smoke signal is dropped, and the telescope is pointed to the floating signal. The horizontal graduation, read immediately, gives the angle of drift.

The determination of the true speed over sea offers a little more difficulty. It should first of all be noted that the vertical arc of the instrument has a series of small notches cut on its edges, and these notches can engage with a small latch mounted on an arm fastened to the telescope axis. Immediately after the smoke signal has been dropped, the telescope is directed towards it. As the signal appears in the field of view, the telescope is elevated to engage the latch with the most convenient notch, so that smoke signal is still below the horizontal cross line of the telescope. Without moving the telescope from this position, the smoke signal will be seen to rise upward until it reaches the horizontal cross line. A stop watch is then started, and the telescope elevated to engage with the following notch. This will cause the signal to move back to the bottom of the field of view, whence it will rise again owing to the motion of the aircraft.

It is easy to see that with the notches appropriately graduated, with the altitude known from the altimeter, and with the aid of the stop watch, the true speed can be calculated. Since these calculations are a little troublesome, special alinement or calculation charts are provided for the pilot. —*A. K.*

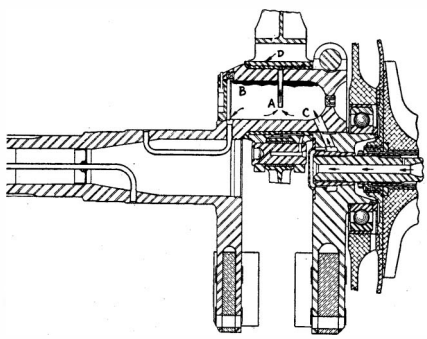
Better Lubrication by Centrifugal Action

CLEAN lubricating oil is recognized as a vital necessity in aircraft engine operation, and oil filters and strainers are standard equipment. No precaution is too great to prevent foreign matter, which may have found its way into the lubricating system, from continually passing through the system and causing bearing wear. Naturally, one of the most vital points of a radial air-cooled engine is the master rod bearing. Here the prevention of excessive wear is of prime importance for dependable operation.



Crankcase and crankshaft of Wright Whirlwind engine after 400-hour endurance test with the centrifugal oil cleaner, showing the sludge removed by the separator

In the new Wright Whirlwinds and Cyclone engines a centrifugal separator has been introduced which will get rid of even very small particles. This new device is illustrated by the diagram. "D" is the master



Cross-section of engine crankshaft and master connecting rod. The letters are referred to in the text

rod bearing mounted on a hollow crank pin. When the engine is in operation the lubricating oil enters this oil chamber through the inlet "C" under pressure at an angle of 45 degrees. Here centrifugal force created by the rapid rotation of the crankshaft, and acting in the same manner as the conventional cream "centrifuge," separates the heavier carbon particles and products of oxidation from the oil itself and deposits them on the walls of the chamber "B," in the form of a soft sludge cake. This mass collects around the base of the tube "A," but it is only the clean lubricating oil that passes through "A" to the master rod bearing. A removable plug at the rear of the crank pin provides for the cleaning of this sludge at overhaul.

The effectiveness of this new centrifugal separator was proved by a recent 400-hour test with a Wright Whirlwind 285-horsepower engine. After the test it was found that the master rod bearing remained in perfect condition with its surfaces smooth and polished in appearance. When the plug was removed from the crank pin and the oil pocket cleaned, more than two ounces of sludge were removed.—*A. K.*

Higher Performance with 100 Octane

AIRCRAFT engines of high compression ratio and with superchargers cannot operate at full throttle near sea level with ordinary aviation gasoline. They either exceed the permissible cylinder temperature of 550 degrees, Fahrenheit, or develop "knock" and roughness, or even cut out suddenly.

Prior to 1928, Army Air Corps engines operated with fuels of about 50 octane number. At present, fuels of 92 octane have been made economically possible. Anticipating a need for a 100 octane fuel, the Air Corps purchased 1000 gallons of "iso-octane." This, blended with a sufficient quantity of aviation gasoline, gave the fliers 2000 gallons of 100 octane fuel.

Tests with the new fuel on pursuit airplanes, powered with Wright Cyclone engines, gave an almost miraculous increase in power. With the 92 octane, the Cyclone could develop only 610 horsepower without trouble. With the 100 octane fuel, the power could be readily increased to 800 horsepower.

It can be seen how desirable from a military point of view (and from a civil aviation point of view, for that matter) is this tremendous increase in power with relatively little increase in weight. There is no doubt that the expense of iso-octane will go steadily down, and that the high octane fuels will little by little displace all other gasolines for aviation use, with a corresponding increase in speed and economy of operation.—*A. K.*

A Modern Airport Beacon

AIRWAY beacons have constantly improved in effectiveness since their inception. The most modern, and in many ways the most complete in function, is the General Electric 36-inch "Bartow" beacon illustrated in these columns.

The rotation speed of 6 per minute, the mechanism for rotating the beacon, the 1000-watt, 30-volt lamp, and the automatic lamp changing mechanism call for no special comment. What is novel is that the spherical beacon is almost entirely "lens" and incorporates three types of beams in the one beacon.

From the photograph it will be seen that the main beam is produced by a "doublet

A new revolving airport beacon provided with three lens systems

lens" placed to the right in the picture. The doublet lens gives a high candle-power beam concentrated to a small angle in both vertical and horizontal planes.

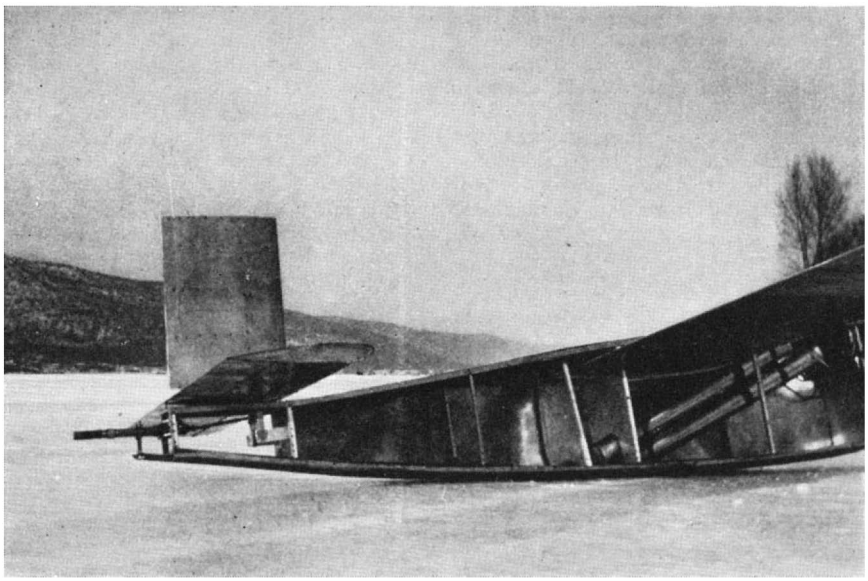
To the left is a spherical Fresnel lens which produces a lower candle-power beam of small vertical divergence but covering 270 degrees horizontally. This Fresnel lens is tipped to the axis of rotation and so produces a wobbling effect in the sky.

On top of the beacon is a ceiling lens, tipped at the same angle as the Fresnel lens, thus also giving the upward beam a distinctive motion, with a giant cone of light traced out in the sky.

On the airways the addition of green or red color screens inside the beacon will indicate "landing" or "no landing" locations and help to eliminate the use of course lights.

What are the purposes of this combination of lenses and "tipped" positions?

First of all there is continuous visibility which prevents eyestrain by permitting the eye to be focused on the beacon at all times. Second, there is distinctive charac-



Side view of rocket plane, showing the fuel tanks

terization; the beacon cannot be mistaken for just a light. Next there is long duration of flash, which every pilot appreciates. The upward beam, besides giving distinctiveness, may be used as a "ceiling" height indicator.—*A. K.*

Automatic Flight

WE have often had occasion to refer in these columns to the Sperry Gyropilot. There are now over one hundred Sperry Pilots flying the fastest ships on the airways. Another device to which we have drawn attention is the Kreussi Radio Compass, built by the Fairchild Company, which permits the pilot to take bearings on any radio station he can tune in.

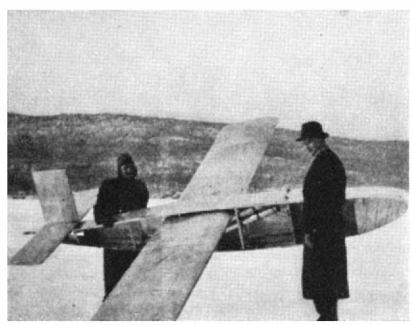
In a lecture before the New York Electrical Society, P. R. Bassett, of the Sperry Company, announces that the Army Air Corps is now trying out a combination of the Gyropilot and the Kreussi Compass. The airplane will then fly automatically towards any station tuned in, and will also be able to fly automatically along any airway radio beam.

Such automatic navigation has great possibilities.—*A. K.*

Airmail by Rocket?

AN unsuccessful but noteworthy attempt to send airmail by rocket plane was recently tried between Greenwood Lake, N. Y. and Hewitt, N. J., a distance of some three miles. The rocket was to carry mail, with full authorization of the Post Office Department, and beautiful stamps had been specially printed for the flight.

The wing and tail surfaces of the rocket mail plane were built of duralumin. The wing span was 25 feet and the fuselage was 11 feet long. The rocket motor was mounted in such fashion that the thrust or reaction passed through the center of gravity. A catapult was to be employed to launch the rocket plane into the air, at the same angle as the subsequent climb under the power of the motor, but in the trial flight, the plane did not take to the air. The motor contained no moving parts and there was no propeller. Two tanks were mounted within the fuselage; one contained liquid oxygen, which at the instant of evaporation has a temperature of minus 200 degrees, Centigrade, and the other contained a mixture of alcohol, gasoline and methane. A third tank contained nitrogen under pressure which was utilized to drive the oxygen and the fuel into the combustion chamber, which was a simple cylinder with a nozzle for the release of the gases.



The experimental rocket mail plane ready for its unsuccessful flight

Once the fuel was electrically ignited in the oxygen vapor, combustion should have continued for some 30 seconds, the products of combustion issuing rapidly from the nozzle providing the necessary thrust by simple reaction.

The undertaking was encompassed with many difficulties, in the motor itself, in the stability of the rocket airplane, and so on, and the final trials were greatly hampered by the intense cold at Greenwood Lake. Regardless of the failure of the first flight, the undertaking is of real technical interest, and the results add just that much more data to the files of the rocket proponents. —*A. K.*

Bomber versus Pursuit

IN aerial warfare, there is a constant change in the relative power of offense of the single seater pursuit and the defensive power of the bomber.

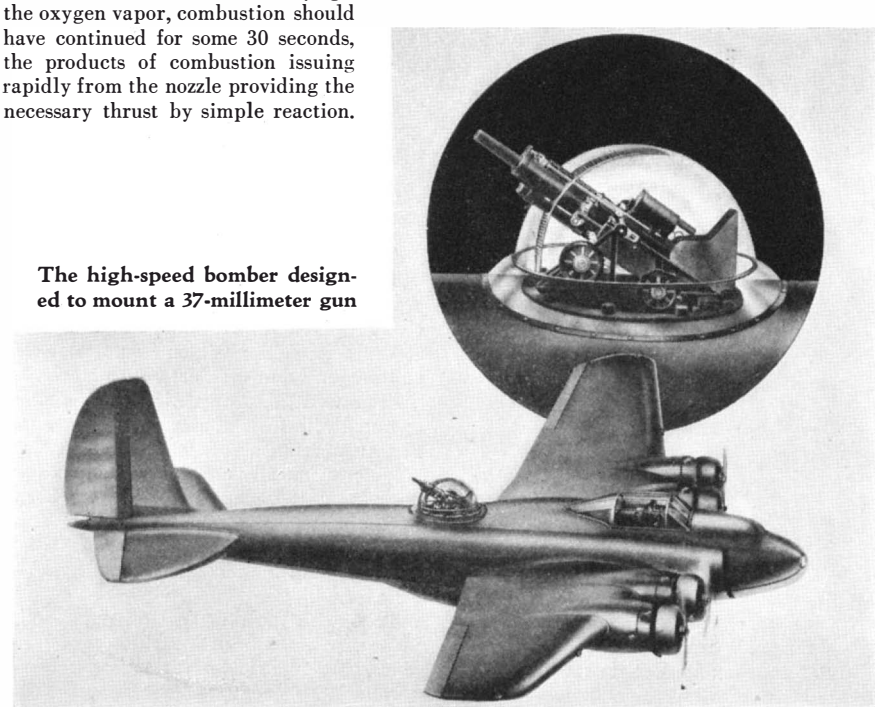
In 1917 the speed of the pursuit exceeded the speed of the bomber by approximately 50 percent. With its greater maneuverability, the pursuit, therefore, had all the better of the argument.

To-day the bomber will do 250 miles per hour; the fastest pursuit does not reach 300; so the speed superiority of the fighter has largely disappeared. But the bomber carries machine guns which are only accurate and effective up to 200 yards range. The pursuit has, therefore, been equipped with 20-millimeter cannon effective up to 500 yards and more. Again the pursuit has become more deadly.

What is the counter-weapon? The installation of still more powerful weapons on the bomber—a 37-millimeter (1.4567 inch) cannon with an effective range of 1000 yards.

So the temporary superiority in fighting of one type and the other will probably continue to swing back and forth.

The new 37-millimeter cannon has been developed by the American Armament Corporation, and is perhaps the most powerful weapon ever mounted in an aircraft. Not only is it more effective because it carries a larger charge, but it is also large enough to handle projectiles which will burst at any pre-determined range. This prevents the projectile from injuring personnel if it should drop in friendly territory during actual warfare.

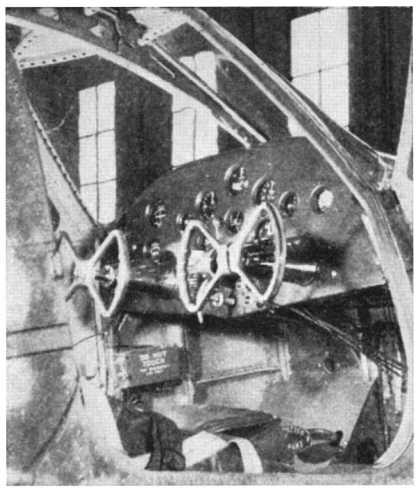


The high-speed bomber designed to mount a 37-millimeter gun

The new gun is mounted in the rear cockpit of the bomber, as shown in the photographs, and is capable of 360-degree rotation, 15-degree depression, and 60-degree elevation. The only restrictions on this zone of fire are those imposed by the location of the wings, fuselage, and tail surfaces.

The gun is mounted in a special shock absorber so that recoil is restricted to a factor low enough as not to affect the equilibrium of the airplane. An elaborate series of tests in the wind tunnel at New York University were also made to balance the gun aerodynamically and make it easy to move when exposed to the air stream. Its construction is as light as possible, thanks to the liberal use of aluminum alloys.

These modern aircraft guns are a far cry from the Army revolvers with which enemy aviators used to salute each other harmlessly at the beginning of the World War. —*A. K.*



Looking into the cockpit of the new two-place coupe for private flying

Coupe for Private Flying

THE Curtiss-Wright coupe is the latest model to be delivered to the Air Commerce Bureau as part of its program for developing airplanes suitable for private flying. The coupe has attracted much favorable comment and embodies many features attractive to the private owner and amateur pilot.

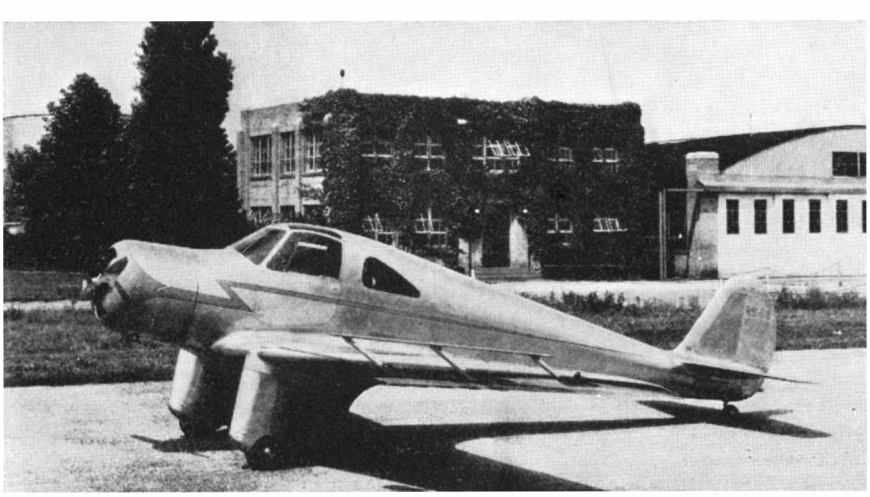
As a two-seater with a 90-horsepower Lambert engine, the new airplane has a top speed of 131 miles per hour and a cruising range of 580 miles with a gasoline capacity of but 50 gallons. Although the wing loading is moderately high—10.1 pounds per square foot—the stalling speed is only 44 miles per hour, thanks to the use of a split flap. The wing area is 173 square feet, the span 35 feet and the over-all length 25 feet 2 inches.

If the lines of the new airplane are examined, it will be found to be as clean and aerodynamically modern as the very latest of our airliners—there are even control tabs on the elevators. This is undoubtedly the right line of approach. Private owners want safety but they also demand aerodynamic efficiency and high speed.

Another feature which makes the Curtiss coupe so much like a miniature airliner is the all-metal construction. The wings are all metal, of the full cantilever type, with a dural skin designed to take a full share of the load. The fuselage is of the "semi-monocoque" type with a metal skin riveted to longitudinals and stringers, with rings or bulkheads at intervals.

Perhaps the most praiseworthy aspects of the design lie in the vision and passenger accommodation. With a low position of the engine, sloping windshield, side windows, and transparent roof, the vision is excellent in all directions. The Curtiss engineers have proved that it is *not* necessary to have recourse to a pusher machine with engine in the rear to secure such adequate vision. The vision is further enhanced by a feature long familiar in automobile practice, but not often resorted to in plane design; namely, the provision of two rear view mirrors in the two automobile type ventilators placed in the roof of the cabin. These ventilators provide "no-draft" ventilation, with the air drawn in through a duct in front of the engine and discharged through the top of the cabin.

The interior of the coupe has been "cleaned up" to the extent of providing a control arrangement which does not require a stick between the passenger's knees. Of course, the idea of the control wheel projecting from the instrument board is not new, but in this case it has been so well worked out as to be considered worth continuing on the production models. Actually, there is a conventional column at the head of the instrument board, placed in an inverted position, to which the wheel shafts are connected. The wheel to the right is fitted with a disconnecting device which renders the wheel inoperative when a non-flying passenger is carried. The foot pedals, which are of the automobile clutch and brake type, may likewise be disconnected on the right side, in which case they lie flat against the floorboard, so that the passenger may have additional foot room. —*A. K.*



A side view of the air coupe, showing its clean lines

Air Camera for Amateurs

IN recent years as air travel has become more common, many passengers on air transports and owners and pilots of private planes have carried aloft cameras with which to snap pictures of their own homes, as they passed over them, or scenes which they wished to record. Such air photography for the amateur has not always been a complete success for it is often difficult to do good work from the air with an ordinary camera. To fill this need, there has now been developed a camera for the amateur built especially for aerial photography.

This new camera is built into a one-piece aluminum case which gives it strength without undue weight. Its streamlined design reduces wind resistance and a large handle insures a firm grip. It is equipped with an *f*/4.5 lens, and incorporates a built-in aero filter that insures sharp negatives through haze. As an integral part of the case, there is a new type brilliant finder which gives a large, upright image. Using standard 3¼ by 4¼ Supersensitive Panchromatic film pack with 12 exposures, it is easily loaded in flight. Its total weight is three pounds and 11 ounces, and its length is 7½ inches.

The air camera for amateurs may be operated with one hand, while retaining complete control of plane

Washington Award to Charles F. Kettering

CHARLES F. KETTERING, vice president of General Motors Corporation, in charge of research, has been elected from a field of 26 candidates to receive the Washington award for 1936. Affectionately known to his associates as "Boss Ket," his agile imagination and bold attack on technical problems have won him recognition as America's Number One researcher and "monkey-wrench scientist."

This award is made annually when deserving candidates are found, as "an honor conferred upon a brother engineer by his fellow engineers on account of accomplishments which pre-eminently promote the happiness, comfort, and well-being of humanity." The winner of the award is pre-

sented with a suitably inscribed bronze plaque mounted upon a marble base. The commission is composed of 18 members, representing the American Society of Civil Engineers, The American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Western Society of Engineers.

Mr. Kettering receives the award as an outstanding engineer who has rendered pre-eminent service in promoting the public welfare through his outstanding contributions to the increase of personal mobility and his driving force for the cause of research as an instrument to increase the welfare and happiness of mankind.—*A. E. B.*

Scent in Lipstick Causes Skin Trouble

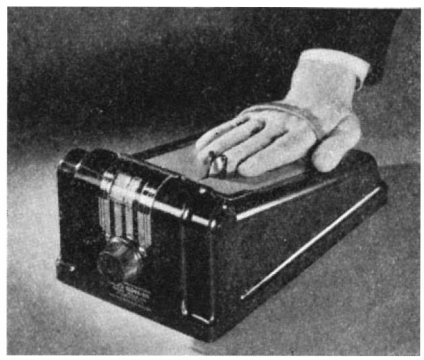
GIRLS should change the scent of their lipsticks if the kind they use brings on a skin trouble. Doctors have traced some cases of lipstick dermatitis—the skin disorder that occasionally develops among users of a lip rouge—to the perfume it contains. A particular offender is a perfume containing methyl heptine carbonate, *The Journal of the American Medical Association* states, according to *Science Service.*

A young woman came to her doctor with a breaking out on the skin, which he traced to her use of lipstick. She had been using a certain brand for years with no ill effects until she changed shades. By patch tests on the girl's arm, the physician found that she was sensitive not to the oil or dyes in the rouge but only to the perfume used in two shades of lipstick of the brand she had been using.

The same test was made on 38 other women. Exactly half of the 38 were sensitive to the lipstick that had methyl heptine carbonate in its perfume. Other possible components of the perfume used in lipsticks gave no reaction.

Gloves Fitted Scientifically

GLOVE-FIT, a new device which measures hand sizes accurately and gives finger lengths in terms of glove sizes, is now being distributed to retail glove counters



Determining glove size mechanically

throughout the country. This new instrument, housed in a lustrous Bakelite molded case, was designed especially for Gates-Mills, Inc., by Prof. A. C. Davis, who is consulting engineer and a member of the engineering faculty of Cornell University.

When a person's hand is inserted through the metal strap, the middle finger pushes against a movable button as far as the stops between the fingers will permit. After this simple operation, the sales clerk turns the adjustment knob until the metal strap is tightened firmly against the hand. Both hand width and finger length are registered on the instrument's dial.

336-TON NERVE SYSTEM

A NERVE system consisting of 110 miles of electric cable weighing 336 tons will be installed on the San Francisco-Oakland Bay Bridge. It will carry electricity to provide 8,000,000 lumens of sodium vapor lighting.

Gadolinium Isolated

THE rare element gadolinium, never before isolated in its free state, has been prepared 98.4 percent pure by French chemists who have devised a new method whereby the metal is obtained during electrolysis in the form of a fusible alloy which is easily dissociated in a strong vacuum. The operation may thus be performed at low temperatures. Cadmium, with a melting point of 320 degrees and a boiling point of 775 degrees, is the alloying metal chosen.

The electrolysis is carried on at a temperature as far removed as possible from the melting point, with fluorine contained in a carbon crucible which serves as anode. The cathode is a mixture of fused salts (gadolinium, potassium, and lithium chlorides) into which the current enters by a revolving rod of molybdenum. The current is seven to eight amperes at 10 volts and the operation lasts 15 minutes. The alloy, which contains 6 percent of gadolinium plus a little lithium, is distilled in a quartz tube under 0.001 millimeters of mercury at 1235 degrees, Centigrade. The tube is cooled under vacuum and filled with carbon dioxide gas. The resulting metal contains 98.4 percent metallic gadolinium and 0.7 percent silicon, but no cadmium.—*A. E. B.*

Admiral Mahan

"AT the request of the family of the late Rear Admiral Alfred Thayer Mahan, I am undertaking to write his biography. It will be appreciated if any readers of the Scientific American who have any letters or other documents concerning Admiral Mahan will allow me to read them. I would also appreciate any well authenticated anecdotes concerning Admiral Mahan. (Signed) W. D. Puleston, Captain, U.S. Navy, Director of Naval Intelligence, Washington, D.C."

Strip for Double Glazing

NOWADAYS as air conditioning progresses and more attention is being given to house insulation problems, there have been many attempts to double-glaze windows to reduce the waste of heat through these openings. One such system, which we described some time ago, contemplated the sealing in of a second pane to create a dead air space between the two. A new method just announced by the Dewey and Almy Chemical Company consists of the insertion of a second pane cut accurately to size and held rigidly in place by a strip of molded rubber compound.

The particular advantage of this system is that all the work may be done right on the job as it is only necessary to purchase

There are two phases to almost every operation in industries where the findings of chemistry are used. In the laboratory the chemist uses delicate test tubes and flasks, searching for the proper way to do a certain thing. Then the plant chemist goes about the same thing, as at the right, mixing the same substances in huge corrosion-proof tanks

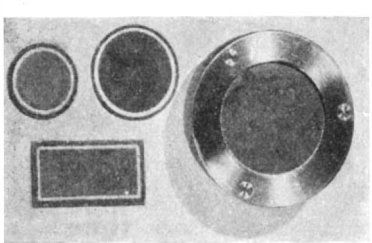
the binding strip in sufficient yardage and have the glazier cut a second pane of glass for each window. The one difficulty in the past has been to have this pane cut accurately as local glaziers are not ordinarily trained to do accurate work. This, however, is a problem which can be overcome by proper care. One further advantage of this process is that the added pane may be removed at any time for freeing the inside surfaces of the panes from any dust that may accumulate.

Chemical Estimates of Earth's Age

At a joint annual meeting recently of more than 500 geologists, mineralogists, and paleontologists, William D. Urry explained his work in measuring the life of rocks by their radioactive decay. By sampling a rock and applying the latest methods of microchemical analysis, Dr. Urry determines how much of the radioactive elements is still intact in the rock and how much has decayed, as indicated by the quantities of lead and helium which are the result. The rocks which make up the Palisades of the Hudson River are 150,000,000 years old; rocks near Duluth, Minnesota, were found to be more than 500,000,000 years old; while rock specimens from other parts of the world showed an age of 900,000,000 years. According to Alfred C. Lane, chairman of a special committee on the measurement of geologic time, these determinations indicated the age of the earth as a planet as not less than two billion years.—*A. E. B.*

Photo Cells for Many Uses

AVAILABLE for the amateur experimenter as well as for the industrial engineer, a new photo cell of rugged construction may now be obtained in a wide range of sizes and in either rectangular or circular form. This photo-voltaic cell, known as Electrocell, consists of an iron plate on which is deposited a thin layer of photo-



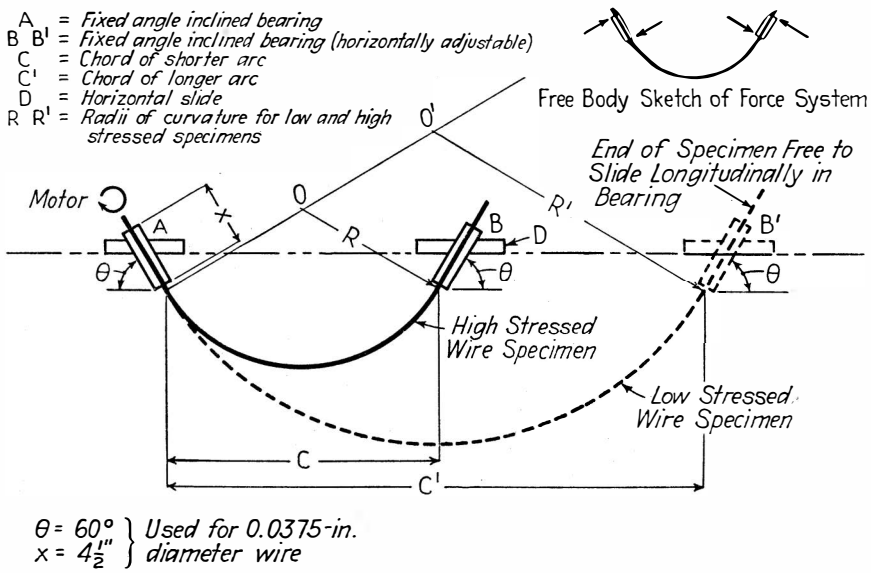
A new rugged photo cell is made in several sizes and in two shapes

sensitive material. This layer is protected by a coating of transparent lacquer, which renders the cell moisture-proof for all ordinary uses except in the presence of salt or acid, and makes it unnecessary to use special care in handling.

In direct sunlight these cells generate an e.m.f. of 0.6 volt, and the smallest of the elements, one inch in outside diameter, gives an output of 1.45 micro-amperes per foot-candle of illumination. At low light intensities the current is linearly proportional to the illumination, and in this range the current obtainable is approximately proportional to the active area of the cell.

The response of these cells to light variations is very rapid and the spectral range extends on both sides of that of the eye, going far into the ultra-violet. Temperature effects on the cell are practically negligible for all ordinary purposes.

It is possible to multiply the current output of these cells by connecting them in parallel. The rectangular shape lends itself to producing a photo-sensitive area of almost any size. The cells may be had mounted in casings with suitable terminals, or unmounted for use in special or experimental set-ups.

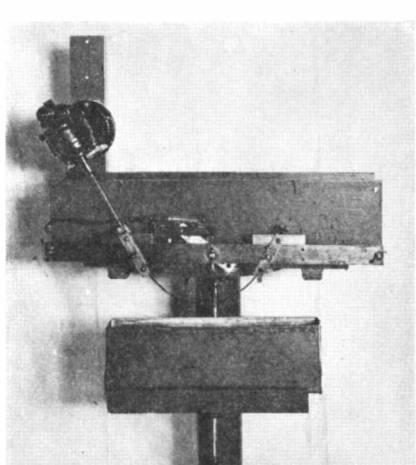


The arcs assumed by a cable wire in the new device described below

New Test for Cable Wire

A NEW method for determining the endurance limit of small diameter wire used in elevator and hoisting cable has been developed at the Engineering School, Columbia University, by John N. Kenyon. Heretofore a consideration of the fatigue limit of these wire materials has been to a large extent neglected because of the difficulties involved in making the fatigue tests. Wire rope specifications call for *static* tests (that is, tension, torsion, and cold bends) and, according to British investigators, give little indication of the true service qualities of these materials. Recent developments may lead to revision in present wire rope specifications.

The new fatigue machine is based on the mechanical principle that a rotating curved wire automatically tends to assume the form of a circular arc. Stress computations are therefore very simple. The wire test specimen rotates at high speed and subjects the fibers of the outer curvature to a tension stress and the fibers of the inner curvature to a compression stress. When a fatigue crack once starts on the surface it is rapidly opened and closed until the wire breaks. The wire specimen is rotated in an oil bath to dampen vibration.



Cable wire under test

The machine is now being used to test wire of .024 to .050 of an inch in diameter used in typical wire rope fabrication. The test method may be used for much smaller wire and has theoretical application to lamp filaments.

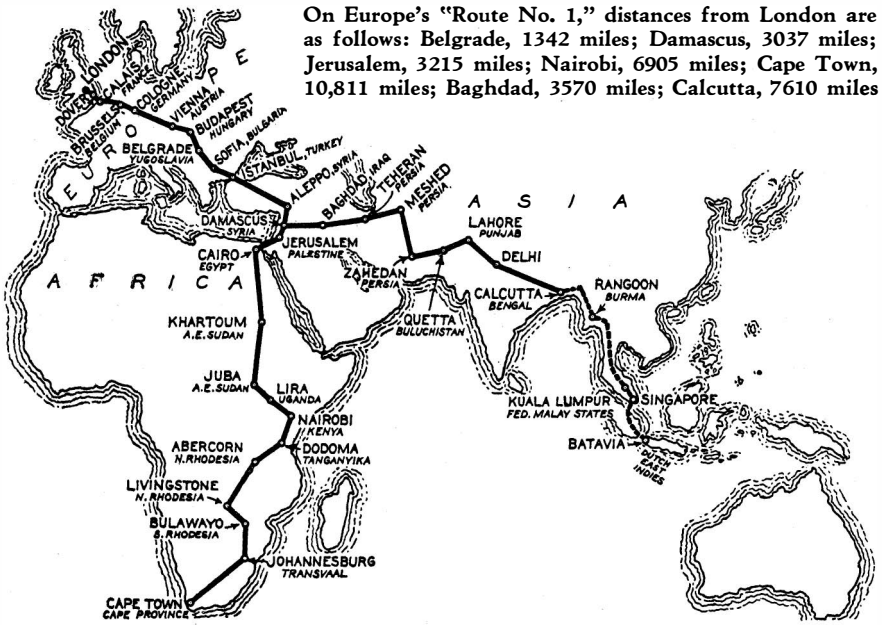
Caesar Not Born By Caesarean

JULIUS CAESAR, contrary to widespread belief, was not born by means of a Caesarean operation, reports *Science Service*. Neither did he have anything to do with enactment of the old Roman law that forbade burial of a woman who died in pregnancy before the body of the unborn child had been removed by surgery.

The old myth about Caesar and his birth is exploded by Dr. John Harold Couch of the Toronto General Hospital and Herbert Newell Couch, assistant professor of Greek at Brown University, Providence, Rhode Island.

A reason for the persistent linking of Caesar's name with the operation is given by the Couches in the *Journal of the Canadian Medical Association*. The reason is quite the reverse of the traditional belief. Instead of the operation being named for Caesar, Julius Caesar's family probably got their name from it. The Couches explain it as follows:

"It is altogether probable that some distant ancestor of his was born by means of a Caesarean operation, performed on a dead mother, and the cognomen of Caesar, which is derived from the verb *caedo*, to cut, was attached to the newborn child for that reason. Another Roman family, bearing the name Caeso, may have derived their cognomen from the same cause. Such a method of assigning names would be entirely in harmony with the early Roman traditions. In fact, Pliny is the authority for this assumption, for in his 'Natural History' he re-



On Europe's "Route No. 1," distances from London are as follows: Belgrade, 1342 miles; Damascus, 3037 miles; Jerusalem, 3215 miles; Nairobi, 6905 miles; Cape Town, 10,811 miles; Baghdad, 3570 miles; Calcutta, 7610 miles

marks that certain people were born by an incision of the mother and that 'the first of the Caesars' was said to have been born in this manner."

Europe's "Route No. 1"

A PARTY of British and Empire delegates drove from London in a fleet of motorcars for the Budapest Conference on the Transcontinental Route from London to Istanbul, which has been called the European Highway No. 1. The Conference, which took place last fall, was convened by the Hungarian government, and aims at rationalizing the organizations existing in each country for the completion of this model highway traversing the whole continent of Europe.

The meeting was unique, for it marks the first occasion that a number of nations have collaborated in the construction of a truly international road, a map of which we have just received. It is reproduced here.

The idea of a transcontinental road was conceived by The Automobile Association of Great Britain in 1930 and adopted with complete unanimity by the Alliance Internationale de Tourisme. The project has received the enthusiastic support of the countries traversed. On two occasions—in 1933 and in June of last year—The Automobile Association surveyed the whole length of the route in collaboration with British car expeditions. Eventually it is intended that the route shall form the nucleus of a system of grand trunk roads extending across Asia to Calcutta and through Africa to the Cape.

Already a good deal of useful construction work has been accomplished along the European section of the route, which in its completed form will be a modern highway for all classes of traffic and not an "autostrada" for private motor vehicles only.

Helical Gears Used in Middle Ages

A HELICAL gear cut out of solid stone some eight or nine centuries ago, and bearing a striking resemblance to present-day helical gears, has been discovered in the ruins of an old castle in Sweden by Otto Lundell, President of the Michigan Tool Company. It is quite likely that the gear was one of a gear train used to drive a community grain crusher. Although the gear has outlived any definite records of the use to which it was put, it shows a startlingly clear conception of gear design for so ancient a period. Note, for example, that the gear is thicker at the hub than at the teeth, to provide adequate bearing area.

At the right for comparison is shown the latest thing in gears—the cone "area contact" worm gear.

Chemical Air Conditioning

CHEMISTRY has come to the assistance of the air-conditioning engineer by developing a simple, effective method of removing excess moisture from air. The conventional method of reducing the humidity is by cooling the air below its dew-point, generally to about 50 degrees, Fahrenheit. Then, in order to make the conditioned room comfortable, this air has to be heated again to about 70 degrees.

That's a foolish procedure and a waste of energy, said the chemist—I can show you how to remove moisture from air without cooling it. So he developed a process of passing moist air through a concentrated solution of lithium chloride, a treatment which will reduce the relative humidity to as low as 11 percent.

Lithium chloride has the present disadvantage of high first cost, but in almost every other respect it proves to be a highly satisfactory drying solution. Lithium chloride solution has proved in practice to be entirely stable, hydrolysis being entirely suppressed at the high concentration. It has relatively low viscosity, is relatively non-corrosive toward most structural materials, is unreactive toward carbon dioxide in the air, is non-volatile, and is entirely suitable for reconcentration by boiling in a commercially practical type of apparatus.

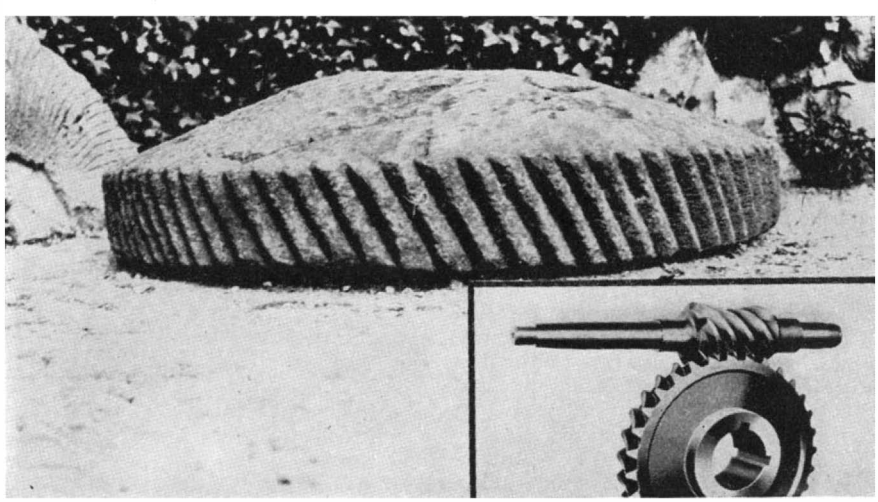
Apparatus has been developed whereby the moist air is passed through towers containing the lithium chloride, which soaks up the excess moisture like a sponge. Then when the "sponge" is saturated, the air current is automatically switched to another tower, while the first "sponge" is "squeezed out"—by concentrating the lithium solution—until it is ready to be used over again.—*A. E. B.*

Septic Sore Throat Traced to Raw Milk

MANY cases of septic sore throat are directly attributable to drinking raw milk from infected cows, according to C. S. Bryan of the Michigan State College, as reported by *Science Service*. Investigation shows that as high as four fifths of herds tested which supplied one large city with milk were infected. In some herds only one cow had *streptococcic mastitis*, but as high as 26 percent were involved. These infected cattle constitute a grave menace to public health because of the contagiousness of the infection.

"Zam" Improves Zinc Plating

IMPROVED electro-plating of zinc is made possible by a newly developed anode material which has been introduced under the euphonious name of "Zam"—coined from the initials of its constituents—zinc, aluminum, and mercury. Zam is not attacked by acid or cyanide solutions until the current is applied. This makes it possible to have an anode free from sludge. No sludge on the anode means no anode polarization. Therefore, practically no increase of voltage will be required at any



A stone gear of the Middle Ages, and a helical gear of today

time. This permits setting the rheostat at a required point with complete assurance that the desired amount of zinc will be deposited in the given time.

When ordinary zinc is used as the anode, a higher voltage is necessary to obtain the required current density, as the anode coats over the decomposed zinc. The higher pressure results in more hydrogen being included in the deposit and, therefore, heavy deposits become brittle and non-adherent. The absence of hydrogen in the deposit, on account of the ability to plate at high current densities and low pressure, makes it possible to obtain a ductile, adherent deposit that can be easily formed without danger of cracking or abnormal distortion. —*A. E. B.*

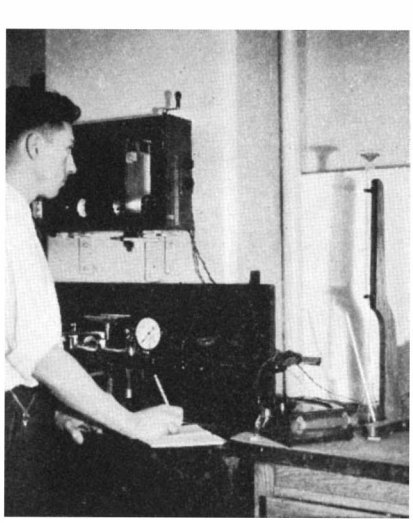
Single Picture Stereoscope

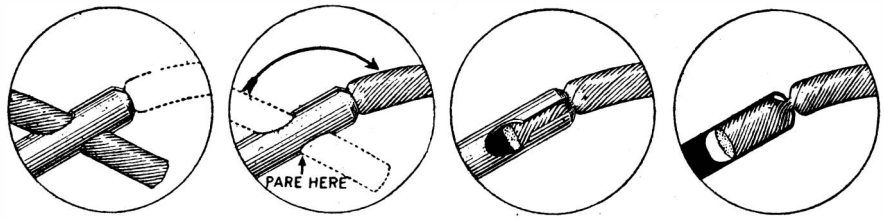
PICTURES and photographs appear real only if viewed with the help of the stereoscope. The necessity of stereoscopic pairs of pictures restricts the use of this fascinating device, very popular a few years ago.

It has recently been found by the Nu-Mirror Company that plane mirrors placed at a slight angle give an enlarged, brilliant, undistorted image of any single picture or transparency, regardless of the size, with such perspective that one has the illusion of seeing the original instead of a pictured copy. The large image in relief reflected by this optical instrument represents the incomplete fusion of two smaller and slightly different images, each image seen with each eye separately. The single picture stereoscope, known as a stereo-mirror, resembles an ordinary hand mirror and lends itself to a variety of optical experiments. Every detail of X-ray films, for example, also can be studied with much more accuracy than by looking at them directly.

Rethreadable Surgical Needle

IN certain delicate surgical operations, it is desirable to have a needle that can be rethreaded easily, and at the same time will make it possible to draw the suture material through the tissue without undue resistance. A needle that will answer these requirements has recently been perfected and is illustrated in one of our drawings. Various sizes are available for use with all of the usual suture materials, which are locked firmly in place after the needle is threaded and the end of the material pared off. The result is that the needle and suture material are of very nearly the same size, making for more ease in operation, and less damage to the tissue.





Steps in threading the new surgical needle, showing the suture firmly gripped

Such needles are especially desirable in operations on ocular muscles.

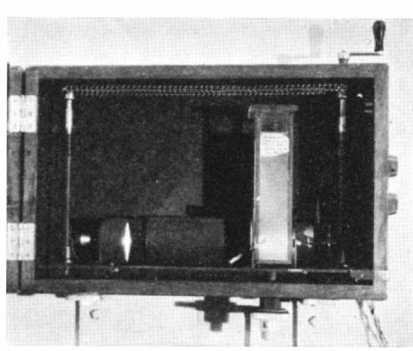
Measuring Minute Cement Particles

COUNTING and measuring cement particles so fine that they are invisible except through a microscope, is a daily routine in the research laboratory of the Portland Cement Association in Chicago.

A device known as a turbidimeter, developed by L. A. Wagner at the National Bureau of Standards, is used in the process. This apparatus embodies a photo-electric cell, and the effects of particles as minute as 1/25,000th of an inch are measured in the following way:

A given quantity of the cement, the fineness of which is to be determined, is placed in suspension in a glass container filled with kerosene. Light passed through the container falls on the sensitive surface of the photo-electric cell, which actuates a micro-ammeter. As the cement gradually settles, the changes in the amount of light intercepted by the cement particles are indicated on the micro-ammeter.

The observer then makes a calculation from the dial reading by which he ascertains the surface area of the cement particles.



***Above:* Glass container and equipment for testing cement. *Left:* Making measurements on tiny particles**

This procedure is a part of the constant research being conducted to determine the relation which the fineness of Portland cement bears to the strength of concrete.

"Optical" Rouge

OUR grandfathers sometimes think the world has gone to the bow-wows, because women nowadays are not stingy of rouge and cosmetics. But a historical study of the times of the 1700's, written by Mrs. Herbert Richardson, a Fellow of the Royal Historical Society, and published in the *Journal of the Royal Society of Arts*, shows that rouge is a thing that comes and goes, while the world goes right on. Writing of cosmetics in general she says: "We decry the vogue to-day for this particular folly, and yet the most highly colored of our modern 'bright young things' would be pale beside her great-great-grandmother. The beauty-doctor's posters were on every wall, her advertisements filled the newspapers, outnumbering those of any other type and purveying every requisite for beauty, even to 'the natural and lasting blush, not to be rubb'd off.'"

Women wore most elaborate head-dresses —erections of hair over some kind of light scaffolding and, says Mrs. Richardson, "Of course all this elaborate hairdressing could not be done every day. A head generally lasted three weeks before it was 'opened,' and nine weeks was as long as it could safely go in summer. One went to bed in a nightcap of the extinguisher variety, made of stiffened linen or pasteboard, or at any rate in a strong net fillet. According to contemporary art, a lady sleeping in all this artificiality of *coiffure* could still look delightful. But in actual fact, the discomfort of the craze, and the state of head with its powder and pomatum untouched for weeks, can only be imagined. An advertisement of 1777 shows, however, that it provided fresh work for the ingenuity of the silversmiths and jewelers: 'The many melancholy accidents,' it reads, 'which have lately happened in consequence of mice getting into ladies' hair in the night time, induced the Society of Art, at their last meeting, to offer a premium to the person who should invent the neatest and most useful bedside mousetrap. A silver trap is now invented by Mr. Moses Martingo, in New Bond Street, price 3 guineas. He also sells nightcaps made of silver wire, as flexible as gauze, and yet so strong that no mouse or even rat can gnaw through them. The caps are sold at 3 guineas each, but the *ton* have them of gilt wire from 6 to 10 guineas.'"

The male Scientific American reader who perhaps has been reading thus far aloud to his wife—anent women's foibles of course—may now read the next to the same listener, if his courage sufficeth. "The man of fashion rivaled his partner in folly, and much profitable trade went to his equipment. This was the era of the Macaroni, so called because macaroni was a special delicacy of Almack's, and the name got applied to the gentlemen who ate it there, and who, moreover, having traveled in Italy, knew how to do so."

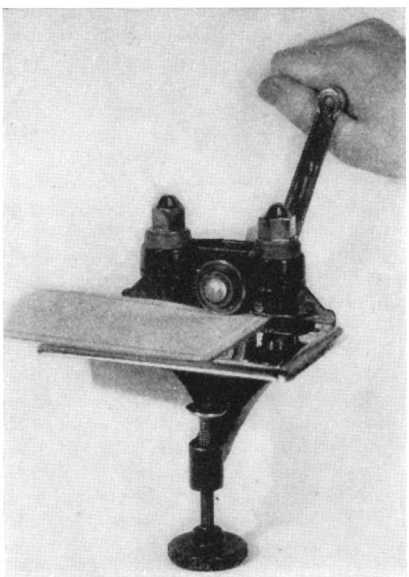
This last no doubt explains the line in Yankee Doodle, which was written in 1753 by a British army officer in America—"He stuck a feather in his cap, and called it Macaroni." And now Mrs. Richardson continues: "Wool, at the advanced price, stuffed the great club of hair at their necks. The florists supplied the nosegay, which had to

be ever fresh; the goldsmiths its dainty holders. Men used rouge and paint fairly constantly, and during the Seven Years' War and other great wars of the period, the newspapers frequently advertised 'Campaign Boxes for Officers, fitted with eau-deluce, rouge, perfumed pomatum, powder-puffs, lip salve and ivory eyebrow combs'—vanity boxes, in fact, for men."

The old-time score—men *vs.* women—evidently stood at about 50-50, and this old world survived thereafter.

Paper Crimping Machine

A BRITISH firm with representatives in New York has just developed an ingenious machine which would prove of value in most any office. This is a machine which will crimp documents together so



Paper crimper for small jobs

that they cling almost as tightly as though sewed, or will seal the edges of envelopes and do any number of jobs necessary in collating office correspondence or papers.

Clamped to the edge of a table or desk, this device is so arranged that its bed lies flush with the desk top. Papers to be crimped pass unimpeded between tightly meshed wheels with small, sharp cogs. The resulting crimp in the edge of the papers is similar to that produced by check protectors or like the crimp used to fasten the jackets of some cigarettes. This machine will crimp as many as four postal cards so that they cling together tightly.

Alnico—A New, Powerful Magnet

A NEW alloy, Alnico, so much more powerful than those commonly used hitherto as to open entirely new fields of application for permanent magnets, has been announced by the General Electric Company. Small motors, and various control devices hitherto operated by electromagnets, can now use permanent magnet fields, at a considerable saving in cost and greater simplicity of construction. Alnico magnets will lift about 60 times their own weight, when designed for that purpose.

Less than a quarter of a century ago the best magnets were of hardened plain carbon steel, developed by cut-and-try methods. Only a few years ago an alloy of iron, aluminum, and nickel was discovered to possess suitable permanent-magnet properties. This alloy contains no carbon and belongs to the precipitation-hardening type of alloys, quite distinct from the steels. The addition of cobalt was the next step; and thus was born Alnico. With the discovery that a precipitation-hardening alloy may possess excellent permanent-magnet properties, an entirely new field of alloys for magnets was opened for research.

The new magnet alloy has a relatively low specific gravity (6.9), is non-corrosive, and is brittle. It is cast in the proper design, and finished by grinding. Any necessary holes should be cored in the casting. Soft steel inserts may be cast in for fastening.—*A. E. B.*

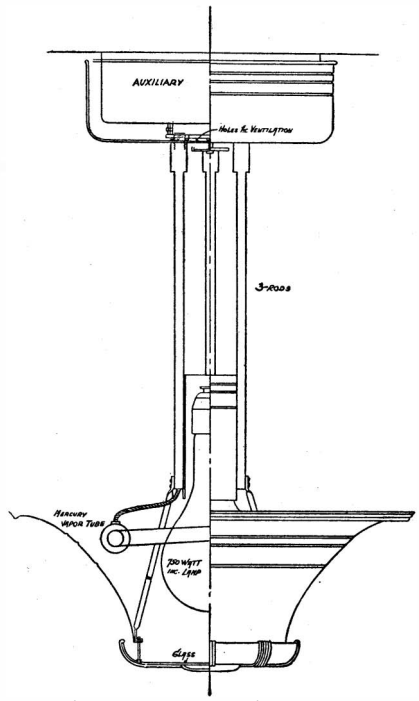
FREE SEEDS

MANY of us remember the old days when Congressmen passed out free packages of seeds to their constituents. Some people remember only too well, for Congressmen continue to be flooded with requests for these seeds. Don't ask for them; they are available no longer.

Windowless Building Features

IN our December 1935 issue we reproduced a photograph of the new windowless office building which has been built by the Hershey Chocolate Corporation. Since publication of that illustration, we have obtained some interesting comments relative to this building from Mr. A. Bowman Snavely of that company.

According to Mr. Snavely, the company felt that, because of the great development of air conditioning, it was only logical that a building of this sort should be put into operation. Such a building would eliminate the uncertainties of daylight and of weather. In the Hershey building, the light, temperature, and ventilation are unvaryingly and



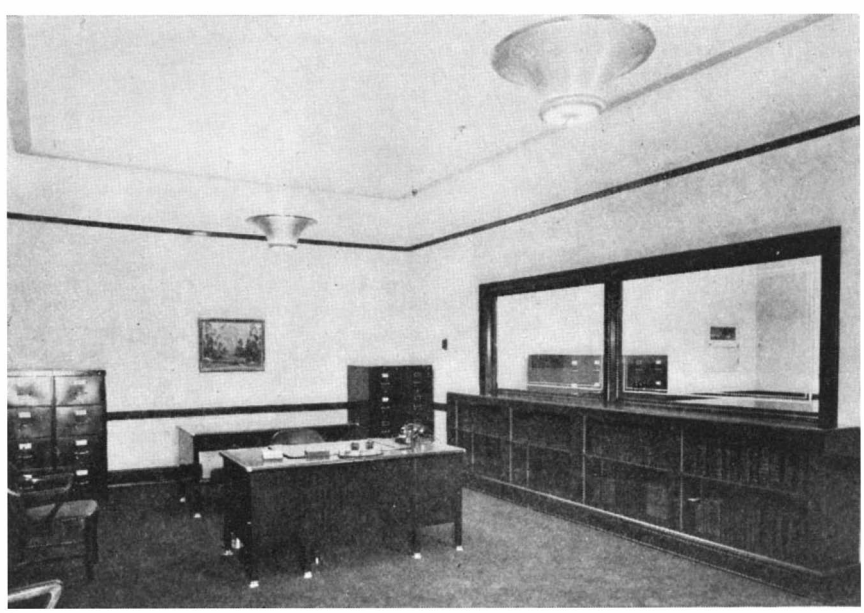
Lighting fixture with ventilation ducts used in windowless building

uniformly established at levels recommended as ideal for physical well being and efficiency.

Of the unique features, one of the most interesting is a weather signal system. Based upon the assumption that the only real reason for a window in a scientifically air conditioned and lighted building is to see what the weather is outdoors, the company installed a system of three colored lights under each clock in the general offices to reveal the outdoor weather conditions in a prearranged code.

One distinct advantage is that all the offices can be grouped on the basis of functional routine without consideration of window area or any question of which employee is entitled to an "outside" room.

Complete acoustic treatment has been given throughout. Ceilings are of Armstrong Corkoustic and this material is finished in ivory acoustic paint which retains the acoustic properties and yet has a high light



A typical office in the windowless building described in the text

reflecting value. Naturally, all external noise is excluded but acoustic treatment was necessary to prevent the feeling of constriction which might result if office noises were echoed from blank walls.

A very important consideration was, of course, the lighting system. Ordinary incandescent lamps are admittedly considerably overbalanced toward the red end of the spectrum in comparison with daylight, so that these alone would not do. Blue-glass bulbs or filters would act to reduce this overabundance of red, but this method is a "subtractive" one which seriously reduces the lighting efficiency. Accordingly, it was decided to use a light unit which combines the light of incandescent lamps with that of mercury-vapor tubes. In this way was produced an "additive" color balance of high visual and electrical efficiency, closely approximating daylight in its effect. The two floors of the building, therefore, use 158 combination mercury-vapor incandescent luminaries produced by the Voigt Company.

This building has been in use only since December, hence no complete report on its benefits are available. It is believed, however, that working efficiency and morale will be considerably improved under the scientific arrangement of the various equipment in this building.

Aluminum Roads

"ALUMINUM and a specially developed tar are credited," says *Municipal Journal*, "with useful results in some road paving trials abroad. A contributor to a German contemporary reports that the addition of powdered aluminum to tar and bituminous surfacings has the merit of insuring high reflecting power, a commendable attribute in itself from a lighting engineer's standpoint. Highway engineers can take cognizance of the statement that the metal keeps —or tends to keep—the temperature of the surface considerably below the normal point, thereby putting a check upon softening in hot weather."—*A. E. B.*

Glioma—Eye Cancer

DOCTORS Hayes E. Martin and Algernon B. Reese, of the staff of the Memorial Hospital for the Treatment of Cancer and Allied Diseases, New York, have reported on a new method of X-ray treatment of glioma of the retina in infants and children, which has not failed in six consecutive cases. Only two of these cases have finished the treatment; one of these children has now been attending school and keeping up in studies for over a year. The others are progressing favorably under treatment.

A notable feature of the method is that the eyesight is preserved, the eyebrows are intact, and only the eyelashes are lost. The doctors made it clear that their report was a preliminary one and that final results could not be proved fully until five years have elapsed.

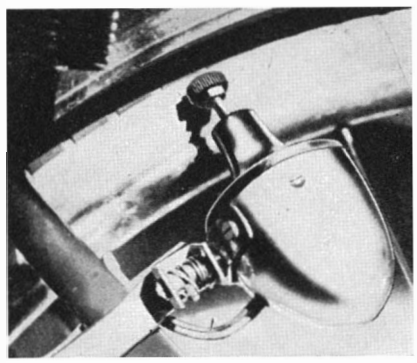
Glioma of the retina is a form of cancer of the eye, which occurs in young children between the ages of two and five years. It is of congenital origin. It appears first in one eye, which is lost, and then often in the other eye, so that if the child survives, it is totally blind.

After many trials, the present method was

finally developed. It consists of the use of small doses of high voltage X rays delivered through several small portals cross-firing on the tumor. The treatment must be continued over several months and sometimes even for a year or more. The tumor slowly regresses, leaving a small scar, encrusted with lime salts, which does not interfere with vision.

Bicycle Generator

BICYCLES have staged a come-back, so it is natural that a new generator should have been designed to supply a suitable source of electricity for bicycle lights. The unit is attached to the frame, under the seat, and a friction disk lightly



Electric generator for bicycles

engages the rear wheel. The generator does not interfere with the rider in any way and may quickly be turned into the "off" position when not needed. Sufficient current is generated at eight miles per hour to light brilliantly both the head light and tail light. It is always ready and there is no need of worry about the lights when they are needed most, which is not always true when batteries are used. The generator is easily and quickly installed on any bicycle.

Colds, 'Flu and Pneumonia

THE road now seems cleared for the conquest of the common cold, influenza, pneumonia, and other diseases of the nose, throat, and breathing organs. The achievements of medical science which have cleared such a "possible" road are reported by Dr. A. Raymond Dochez, professor of medicine in Columbia University School of Medicine, according to *Science Service*.

The common cold and influenza occupy "the key positions in the whole pattern" of infection of the breathing tract, Dr. Dochez has concluded as a result of studies by himself and other medical scientists. These two diseases are caused by agents known as filterable viruses.

If an effective means of vaccinating against these two diseases could be developed, it would mean not only control of the colds and influenza but also a possible lessening in the amount of all serious bacterial infections of the breathing organs, Dr. Dochez gave as his opinion.

Asserting that the goal of his studies on respiratory disease and a possible road to it have become clear, Dr. Dochez described the following achievements which helped to clear the way:

1. Studies showing that the common cold is caused by a filterable virus.

2. Growth in the test tube of large amounts of the cold virus, which has been kept alive outside the body for 20 months.

3. Growth of the virus of influenza in the test tube.

4. Transfer of the influenza virus from man to the ferret and from the ferret to the white mouse.

5. Discovery that the influenza virus from different parts of the world and obtained at different periods of time is very similar in its activity.

SPEED

MAN can out-spin the silkworm but man does this fast spinning in glass. The silkworm requires several weeks to spin 6000 feet of silken fiber but the glass manufacturer can draw molten glass into a smaller and stronger fiber and can equal the silkworm's yardage in three seconds.

Explosion Menace

WARNING of a new explosion menace was recently given by the famous Johns Hopkins University physicist, Dr. R. W. Wood, before the meeting of the American Association for the Advancement of Science. The detonator caps used to set off dynamite blasts are causing damaged fingers and blinded eyes and occasional deaths when they are found in quarries by children or lost in coal during mining. Dr. Wood recently investigated the mysterious death of a Baltimore woman which occurred while she was stoking the furnace. A cap left in the coal had exploded and a small pellet of copper no bigger than the head of a pin was blasted through her breastbone, severed a large artery, and caused death. Experiments by Dr. Wood showed that the minute projectiles are driven by the explosion through even the thickness of two telephone directories.—*Science Service.*

Oil Lines Bridge Highway

THE three 8-inch and three 12-inch pipe lines shown in one of our photographs, carrying gasoline and oil (in the raw), rise out of Kansas plains to give a future highway's traffic the right of way as it dips under a railroad. Carrying the lines over, instead of under, the highway saved considerable work and avoided a low point in the line. These sleek-lined, arc-welded, petroleum carriers, built by Sinclair Pipe Line Company, will remind passing motorists that this is an era of good looks and efficiency for more than cars, trains, and ships.

Prevents Plant Growth on Masonry

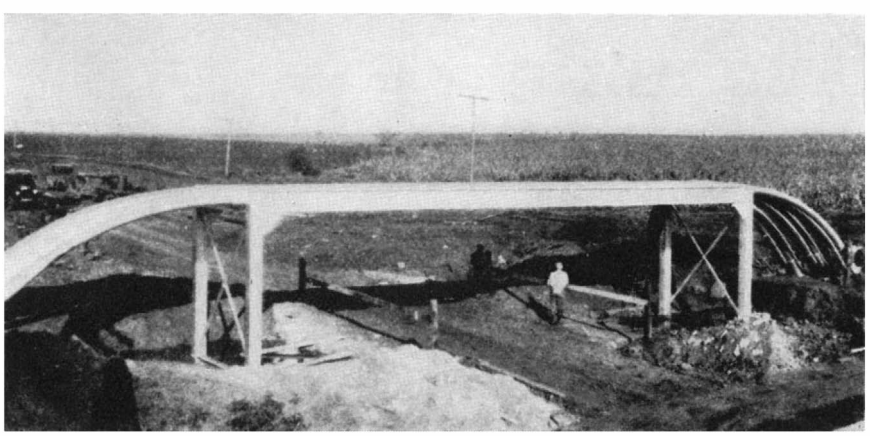
ACCORDING to a Swiss inventor, H. Zimmerli, the growth of plants on walls of masonry can be controlled by adding to the mortar—for example, in the case of water reservoirs, beach walls, and the like—substances that prevent the germination and growth of plants. In particular, good results are obtained with the addition of three parts of sodium chlorate and two parts of iron sulfate to 100 parts of quartz sand mortar. It is especially recommended that some sodium fluoride or colloidal silver also be added. Finally, the hardened plaster is sprayed with a dilute emulsion consisting of boiled linseed oil, wool grease, ground fluorspar, ammonia, and 2-percent copper sulfate. This treatment is claimed to be very effective.—*A. E. B.*

New Dust Replaces Arsenic

SEARCH for a non-poisonous insecticide that might be substituted for arsenic and that, at the same time, would give effective control of insect pests of vegetables, has been rewarded by the discovery of derris, a tropical plant from which a dust possessing marked insecticidal properties can be produced. Entomologists at the State Experiment Station at Geneva, New York, have tried out this new material against worms on cauliflower and against the Mexican bean beetle with a high degree of success.

"Although derris is commonly referred to as a new insecticide, it is well to remember that centuries ago natives of Borneo and the Malay States used this plant as a source of poison for fish and for their arrow heads," says a statement from the Experiment Station on this subject. "The fact that it is non-poisonous to man when taken through the mouth has recently given impetus to its development as an insecticide. The dust is made from the ground roots, and it is generally agreed that the chief active ingredient is a substance known as rotenone. A good grade of powdered derris root will contain 4 or 5 percent of rotenone."

In tests carried on by Station specialists, ground derris root diluted with talc so as to give a dust containing 0.5 percent of rotenone has given effective control of caterpillars on cauliflower and of the Mexican



How oil lines are carried over a highway under construction

bean beetle. The method and frequency of application should follow much the same program as that employed in the use of arsenical dusts.

"In general, it will probably be more satisfactory to purchase the material ready mixed unless the grower has good facilities for mixing dusts," concludes the statement from the Experiment Station. "Owing to the fact that derris deteriorates rapidly on exposure to air and light, the container must be kept tightly closed between applications. Dusting should be at the rate of 25 or 30 pounds per acre, and the material can be applied with a power duster or with a good rotary hand duster. In gardens or small plantings, the dust may be placed in a cheesecloth sack and sifted over the plants."

3300 GYNANDROMORPH ANTS

SEX mixups of a most fantastic kind, involving at least one fourth of the population of a large colony of ants, were described by the noted American entomologist, Prof. William Morton Wheeler of Harvard University, in an address before a recent meeting of the British Association for the Advancement of Science. The colony was discovered on the British-owned island of Trinidad last spring, by Dr. N. A. Weber, and was studied jointly by Dr. Wheeler and himself.

The mixed-up condition consists in each affected insect being partly male and partly worker-female or "neuter." In many, the front part of the body looks like that of a male and the back part has a female appearance. In others, "islands" of femaleness appear in the midst of male areas, and vice versa. No two of the insects thus far examined are alike in either the degree or distribution of their assorted sexualities.

In the particular species to which this colony belonged, Dr. Wheeler explained, the males have longer legs than the females. Some of the "sex-assorted" ants had male legs on one side and female legs on the other. The result was that they could travel only in circles, like the famous but fabulous "side-hill gouger" of western American myth.

In all, Dr. Weber has counted some 3300 of these peculiar ants, all of them being offspring of the same queen ant, who was herself apparently normal in every respect. Insects and other animals that display such a patchwork of sex characters are known to science as "gynandromorphs." Taken to pieces, this tough-looking Greek word means "female-male-forms."

Science Service

ACCURACY IN HIDE FINISHING

MILADY'S gloves must be delicate, thin, and flexible. Mere man can stand heavier materials, and is not so particular about whether the fit is skin tight or not. But nature does not make animal hides of uniform thickness, and it is necessary for glove manufacturers to "shave" the tanned hides to uniform thickness. This operation consists of passing the hide under a rapidly revolving abrasive roll, which grinds off the surface and reduces the thickness to the desired degree.

Ordinary grinding is one thing, but hide

Preserving Proof of Invention

EVERY inventor who is working on a device which he contemplates patenting should first prepare sketches and a description of his invention, which should be dated and witnessed by at least two persons. The inventor has thus established the date of his disclosure, and such evidence should be deposited in a safe place from which it may be produced when needed.

When an invention has been completed, it is advisable to file an application for patent without delay. However, we realize that many inventors today do not have sufficient funds to meet this expense, nor have they safe places in which to keep their disclosures. Therefore Scientific American will undertake to act as a depository for such documents without charge. These will be held in safe-keeping for two years (unless withdrawn by the depositors) and then destroyed without opening.

To take advantage of this offer, place your papers in a sealed envelope endorsed with your name and address and marked "Not to be opened." Then enclose this in another envelope addressed to A. P. Peck, Associate Editor, Scientific American, 24 West 40th St., New York, N. Y., and mail.

—The Editor.

finishing is another, and extreme accuracy is required. The least wobble in the roll would ruin a hide. This might not seem to be such a problem until one realizes the size of a hide. The Curtin-Herbert Company, however, makes a machine that meets these requirements without any difficulty.

The machine which does this work has a roll 50 inches long, directly connected to a five horsepower motor. This roll is covered with fine emery dust or extra fine sandpaper and turns at 1155 revolutions per minute. To insure freedom from friction and to guarantee accuracy of adjustment, the grinding roll is mounted at both ends on Timken tapered roller bearings.

The adjustment of the grinding roll is so delicate that a piece of newspaper or a magazine page may be passed under the roll and only the surface ink will be removed, without cutting through or tearing the paper. This means that only about a thousandth part of an inch, less than the thickness of a human hair, may be removed.

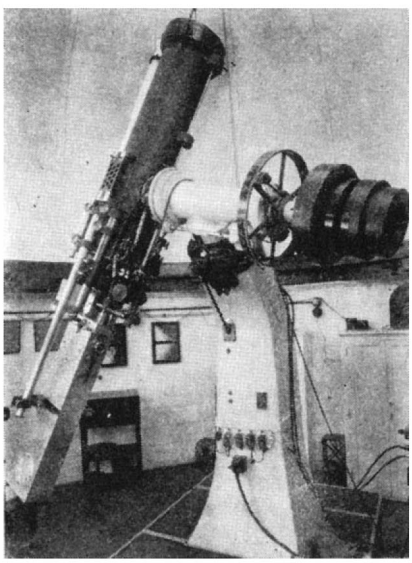
With equipment capable of such accuracy over a 50-inch span, many hides that would otherwise be made up into men's gloves or shoes can be worked to the delicate thickness required by women in their fancy gloves. Surface blemishes and flaws in the face of the hides can be eliminated without injuring the body of the hide. Absolute uniformity without even a thousandth of an inch of wastage in thickness can be main-

(*Please turn to page* 224)

THE AMATEUR TELESCOPE MAKER

Conducted by ALBERT G. INGALLS

THE matter presented below, regarding the McMath-Hulbert Observatory, is a continuation of the short article on page 176, the intention having been to segregate there the less technical parts of the account, and to reserve the remainder for this department; thus not offering it to those of the general readers of the magazine who are not telescope enthusiasts such as the readers of this monthly department are. The following added data were furnished by Robert R. McMath, the director of the observatory, at our request.



Spectroheliokinematograph and 10½″

"Reference to the picture [page 176.—*Ed.*] will show the dome which houses the 10½″ Pyrex reflector, in the lower right hand part of the picture. This instrument is carried by a Bruce type mounting and is used with many different combinations. Quartz secondaries provide for focal lengths of 200″, 540″ and 850″. A 6″, *f*/6.5 Petzval lens, which is often mounted on the side, provides speed and wide angle.

"Early in 1932 work was started on an instrument which we christened the 'spectroheliokinematograph'. Essentially this instrument is a spectroheliograph plus a motion picture camera and such an instrument makes it possible to photograph solar phenomena in the light of some chosen wave-length or element alone. The addition of the motion picture camera has made it possible, for the first time, to secure continuous records of solar phenomena. The spectroheliograph has for its optical train a Littrow type spectroscope employing a 4″ Ross collimating lens of 72″ focal length. This lens was designed by Prof. Ross and made especially for this instrument. A 4″ grating, 20,000 lines to the inch, is in service at this time and the spectroscope, plus the camera, is mounted on the 10½″ equatorial telescope. Those who are interested in detailed descriptions are referred to the various publications of the University of Michigan Observatory" [usually available for consultation at the different professional observatories, but otherwise difficult, at this date, to obtain.—*Ed.*]

In describing the new solar tower, McMath writes: "If the reader will refer to the accompanying line diagram, it will perhaps be easier to follow this description. Experience has taught us that there is no substitute for mass in designing a photographic telescope. Consequently, all parts of this instrument are very heavy. As an illustration, the combined coelostat and flat mountings will weigh a little over six tons.

"Our dome on the solar tower is 17′ in diameter inside, and the effective shutter opening is 4′. We used a standard water tank bottom for this dome and cut the shutter opening out with a torch. The base ring is an 8″ x 6″ x ½″ angle and the weight is carried on eight rollers, spaced at 45°. An additional eight spacing rollers keep the dome concentric. Construction is entirely of welded steel.

"The outside shell is 17′ in diameter and the inside tower is 6′ in diameter. Each tower is supported on its own columns and the foundations for each set are separated. Optical tests made show that no vibration is transmitted from the outer shell to the inner tower, which carries the coelostat. The workroom is 28′ in diameter inside the octagon, giving ample space in which to work.

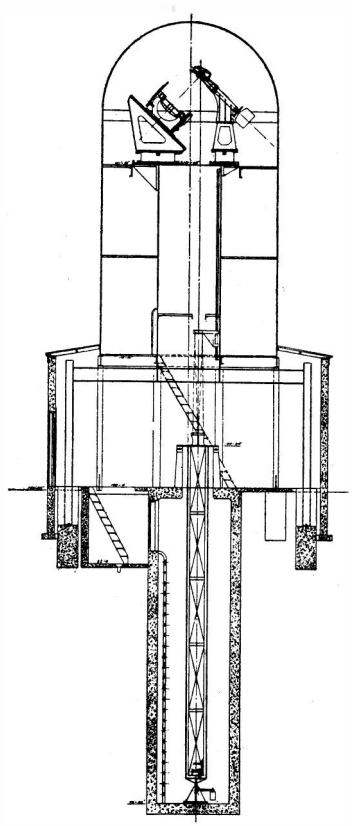
"Entrance to the spectroscope pit is through an underground photographic darkroom, which will be provided with water and necessary equipment. The pit is 7′ in diameter and 30′ deep. It has an inner steel lining which was welded water-tight. This pit houses the spectroscope and is provided with a steel cage 2′ square, of which about two thirds is carried on the bottom bearing and the remaining one third on the upper ball bearing in the pedestal. The pedestal, at ground level, is 4′ high and the actual, net working surface of the rotatable pedestal top is a circle whose diameter is 52″.

"The coelostat mirrors are of optical Pyrex. The first mirror is 22″ in diameter and 5¼″ thick. The flat is 18″ in diameter and also 5¼″ thick. Sunlight passes through the shutter to the coelostat mirror, thence to the flat mirror, and then straight down the inner tower to a 12″ parabolic mirror of 20′ *e.f.l.*, at the pedestal. This mirror is figured off-axis, and returns the now converging beam back up the inner tower to a 9½″ Pyrex flat [Note bracket.—*Ed.*] This flat reflects the converging beam to its focal point on slit No. 1 of the spectroheliograph. Provision has been made at this point for the use of a 16″, 40′ *e.f.l.* mirror to give a larger image of the sun.

"Light from the first slit of the spectroheliograph travels down the pit inside of the cage to the collimating lens. We expect to use either a 15′ or a 30′ spectroscope, as the need may arise. This diverging beam passes through a 6″ clear aperture collimating lens and falls upon a 6″, 15,000 line plane grating. Light of the desired portion of the spectrum is returned by the collimating lens to the second slit of the spectroheliograph. The camera is, of course, focused on the second slit. These slits are arranged to move in opposite directions at exactly equal speeds and the resulting picture is a spectroheliogram taken with light of one wavelength.

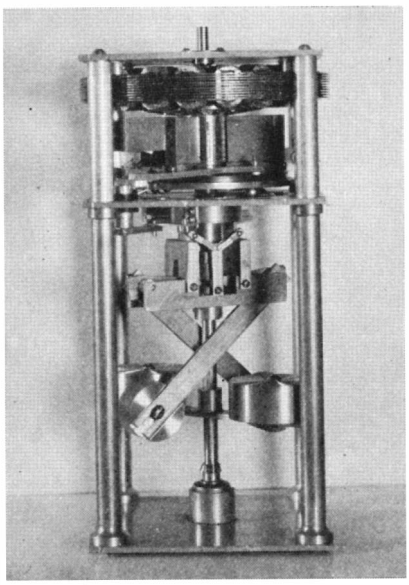
"The coelostat and motion picture camera will be driven by the present equipment located underground, to the northeast of the 10½″ dome. All other slow motions, driving rate controls, chronographic recording, mechanism for controlling ratio of light to dark time on the motion picture film, and so on, that have been found essential in our previous work, are also electrically controlled in the new tower by merely extending the electrical circuits from this underground control room. Our method of driving and controlling equatorial telescopes has been described in the *Publications of the University of Michigan Observatory*. Space prevents a detailed description at this time, but it may be said that the reason for building a solar tower at this location is because of the fact that the existing equipment can be used in toto.

"Some years ago the entire observatory was given to the University of Michigan and is now operated as a branch of the University of Michigan Observatory. It has been financed entirely by private gifts. If a satisfactory example of an amateur is an individual who fails to make money following a hobby, then the present director and staff are amateurs de luxe.



Elevation of the solar tower

"All of our equipment is 'home-made,' and has been built from designs made largely by the present director. The mountings and so on have been made by the Motors Metal Manufacturing Company of Detroit, the steel work and so on by Whitehead and Kales Company of Detroit and, with the exception of the two large mirrors for the coelostat, the optical parts are from J. W. Fecker, of Pittsburgh, Pa. The two



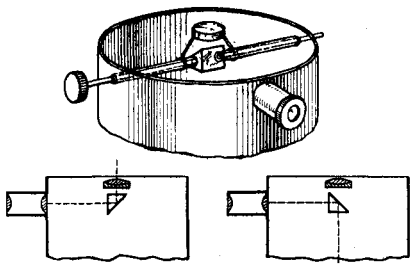
A close-up photograph of a clock drive made by E. H. Morse, of Altadena, Calif. It drives the 15″ reflector shown on p. 355, "A.T.M."

coelostat mirrors are being figured by the Warner and Swasey Company of Cleveland, Ohio."

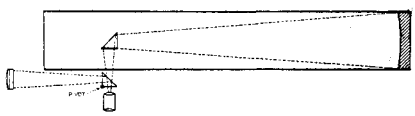
The spectroheliokinematograph described above by McMath and shown on the opposite page consists of a metal box weighing 70 pounds containing a modified (shortened focal length) Hale spectroheliograph and a 35 mm. motion picture camera. Anderson prisms are used, and are driven by a small air turbine. A day's photography of the sun consists of about 600 separate spectroheliograms, and these give a motion picture when run off rapidly. With the solar tower equipment as many as 720 exposures per hour will be obtained.

THE following is a suggestion made by J. R. Haviland, 426 Second Ave., Lyndhurst, N. J., under the heading "Things to Try." Perhaps someone will try it out. "A German patent formula for preventing tarnish on silver (used on silverware) might be tried out on silver films. Solution of potassium chromate in water. Immerse silver at room temperature 5 to 10 minutes. The very thin layer of silver chromate formed is transparent and protects the film. May not work on a mirror."

SOMEWHAT belatedly we have run across an article on "nervous breakdowns," in the April, 1935, number of *Fortune*. This states that telescope making is being used as "occupational therapy" at a mental sanitarium in the mid-West. Whether it will help the patients or drive them quite crazy is something of a question. Perhaps the wives of those who read this department and follow the hobby will throw pertinent light on this matter.



Wyld's prism-finder combination



Parks' finder-prism combination

THE dingbats shown above are combinations for using finders without added inconvenience. The one at the top was suggested by James Hart Wyld, 307 Foulke Hall, Princeton, N. J. The regular prism carries a finder objective on a bipod or bracket, and is rotatable against stops. The lower one is by M. C. Parks, Electric Vacuum Cleaner Co., Cleveland, Ohio, and, like the first, explains itself. In both cases the prisms rotate.

HERE are some solid data from Horace H. Selby, a chemist, of San Diego. "Since last you wrote," he says, "I've attempted to compare the Foucault test with the Ronchi, on several surfaces, both directly and with a flat. Briefly, my conclusions are:

"*1:* The two methods are equal in sensitivity at *f*/6 direct, and at *f*/12 with a flat.

"*2:* Ronchi is better at large aperture ratios: *f*/1, *f*/2.3, *f*/4.5.

"*3:* Foucault is better at small ratios: *f*/6.8, *f*/8, *f*/10.

"*4:* Neither is sensitive enough (±0.1 wave) below *f*/4.5.

"*5:* Straight-edge, diffraction (Everest test) and Ronchi are equal for edge.

"*6:* When using a flat or a Hindle sphere, these surfaces must be pretty near to fairly good: ±0.1 wave is none too close.

"All of the above was done with 120-line-per-inch Lower wire grating and smoked razor blade. In all comparisons, source (pinhole) and eye were precisely together on the axis. Surfaces used had apertures of 1.09, 1.4, 2.3, 3.5, 4.5, 6, 8, 10 and 11.3. Sensitivity was judged by polishing grooves in surfaces with pitch laps ⅛" diameter, loaded 50 grams per square centimeter, and using black rouge washed from old, worn-down stock.

"Don't forget," Selby adds, "that others may not get the same results."

Comments on the above: Everest—"I choose the old tin can and razor blade." Sheib—"Interesting. I agree with Selby on No. 3, also No. 4 and No. 5. I am not sure I agree with him on No. 1 or No. 2."

Well, there it is—now it is a public fight, along with who is going to be the next president. Great pains should be taken to eliminate variables, in making tests similar to these.

HERE are some further data from Selby who is the one who made the "dinosaur" telescope described last July, also a whole fleet of flats.

"Regarding the cutting speeds of polishing materials," he says, "I find:

"With very hard pitch, No. 600 pits, load 50 grams per sq. cm., stroke 250" per min:

	Rouge	Black Arg. Glass	Plate	Pyrex
B. and L.		9 hrs.	8 hrs.	10 hrs.
Am. Opt. Co.		5½ hrs.*	6 hrs.	5 hrs.
H. W. and M.		8 hrs.	7½ hrs.	10 hrs.
Clark		10½ hrs.*	9 hrs.	
Black "rouge"		12 hrs.	11½ hrs.	14 hrs.

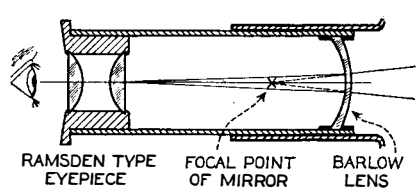
"*Remarks:* Black glass is softest, Pyrex hardest. Surfaces made with B. and L., H. W. and M., and Clark, equally good; Am. Opt. Co., worst; black, best. All trials were duplicates, except those starred, which were singles. Pyrex shows more shallow pits, grade for grade, than the others. These results are not precise, but they are comparable; for example, fine grinding was uniform in all cases—same stroke, speed, same loading, same percentage of Carbo. in suspension.

"Very hard laps of pure pitch polish much slower than pure pitch laps of medium hardness on Pyrex.

"Regarding tendency to scratch, with superhard laps on Pyrex, B. and L. sleeks and scratches least, Clark next, then Fuller's black, then Am. Opt. Co., and worst, H. W. and M.; although, with a medium lap, none scratches at all."

Naturally, this is only one man's findings. He does not claim they are final.

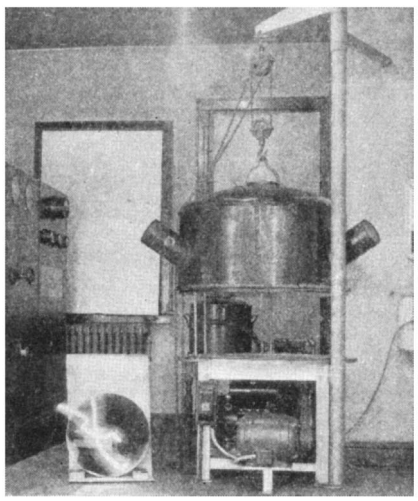
In Selby's notes, "Black Arg. Glass" refers to a special melt called "Marbletex," from Wells Glass Co., Kokomo, Ind. "H. W. and M." refers to Hanson, van Winkle and Munning Co., East Matawan, N. J. "Clark" refers to Alvan Clark and Sons Co., W. Somerville, Mass. The other two are mentioned in "A. T. M." The black "rouge" was from W. P. Fuller Co., San Diego, Calif. Binney and Smith, 41 East 42 St., New York, make black rouge but your scribe has not yet tested it. Some black "rouge" which H. A. Lower sent him proved to be as scratchless as a newly hatched chick. It is slow (note Selby's figures), but after no end of trouble with scratches Lower found it a haven of rest.



Hiner's Barlow eyepiece layout

THE cut above shows how W. B. Hiner, 123 Cleaves Ave., San Jose, Calif., added a Barlow lens to an eyepiece. In this case it was one component of an old camera lens, a meniscus. The Barlow principle is explained by Hindle, in "A. T. M.," p. 215. If the lens is arranged to slide along the axis, as explained in "Splendour of the Heavens," p. 751, the amount of magnification may be varied at will.

A NEW aluminum evaporating outfit installed by Leroy M. E. Clausing of Chicago is shown opposite. He writes: "The enclosed print is one that I made of the evaporating outfit. The streaks of superbrilliancy on the 20" flat are not caused by super-reflection, but are due to my moving the light to the wrong place while taking the picture.



Clausing's new evaporating rig

"Starting at the floor, you first see the 2 H.P. motor that drives the 'Hyvac 100' pump, which is right back of it and is only partly visible. It gives a final vacuum of 3 x 10^{-5} mm. of mercury. Above this is the heavy reinforced steel plate upon which the steel 'jar' rests. The steel jar with its ports may look like a Buck Rogers contraption, but the extensions are merely to keep the aluminum vapor from reaching the glass ports. There is approximately 18,000 lbs. pressure on this jar when exhausted, but it stands up O.K. In the rear you will see a small steel jar which I use for small mirrors and special work."

Perhaps others who do evaporating will send in similar pictures.

THE following communication, entitled "Science and Facts," has been received:

"So-called modern science teaches that the earth revolves or rotates on an imaginary axis every 24 hours; and that the sun is stationary; and that the earth whirls around the sun once a year. It also claims that the sun is a larger body than the earth, and that the sun is 93,000,000 miles from the earth.

"It can be proved by more than 100 different facts that this is all nonsense and imagination.

"In the first place, the earth is too large and too heavy a body to be able to rotate or to revolve. Such a movement would also be perpetual motion.

"It would also be impossible for the earth to rotate or to revolve evenly and regularly, on an axis, every 24 hours, as the axis would sooner or later wear away, thereby causing the earth's poles to become lopsided, which would then cause the earth to rotate or to revolve unevenly and irregularly.

"It would also be impossible for us to live more than a few minutes, with the earth traveling at such a speed as 1000 miles an hour, as we would all soon suffocate. And it would also be impossible for the clouds, traveling at the rate of 40 miles an hour, to catch up with the earth. It would also be impossible for the sun to heat and warm the earth, with the earth traveling at the rate of 1000 miles an hour, as the earth would soon freeze up solid in a few days."—W. J. BARTH, *Howard Lake, Minnesota, Authority on Science.*

Let Timken, S-K-F, Hyatt engineers install bearings that won't permit the earth to wobble.

CAMERA ANGLES

Conducted by JACOB DESCHIN

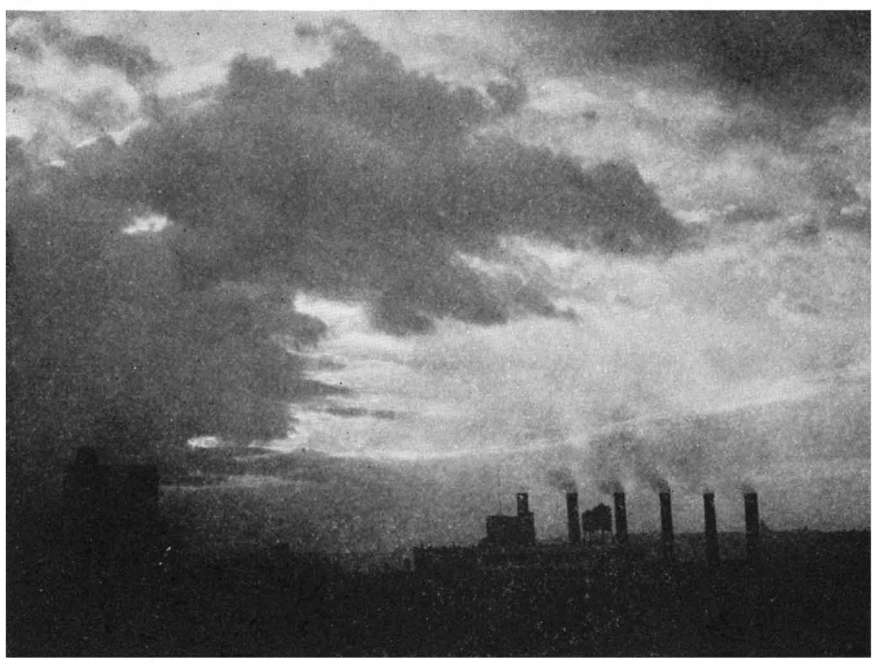
New Fields to Conquer

A FACTORY smokestack used to be regarded by the camera hobby fraternity as a disgrace to the landscape; today it is often the other way about. Many workers prefer it. An explanation may be that economics, once a dull subject about which dull academicians wrote dull treatises, is today a living issue discussed with zeal, varying degrees of knowledge, and more or less intelligence in the "best" circles as in the humblest. With heads out of the clouds and feet squared firmly on Mother Earth, we survey life's realities and fear them not. We photograph them. We see beauty in smokestacks and in factory interiors, in gears and motors, girders and concrete mixers, the varying phenomena of construction in a world that, for better or worse, moves ever forward in material expansion and growth, and, in this very movement, as well as in its static moods, presents the photographer with widely varying material. All he needs is an eye that "sees"—in the photographic sense.

The gleam of machinery, the blinding brilliance of rushing metal, the grace of a swinging crane—these are but aspects of the new, realistic approach. The scientific laboratory, with its test tubes and retorts, the waterfront at cargo loading time, men at work on bridge tower and skyscraper, "holing" through a new tunnel, shaping hot metal—these and many other subjects are now the happy hunting grounds of the pictorially minded.

Recently a newspaper queried the photographic agencies for a "dramatic" picture showing a freight car being loaded. Formerly such a request would have seemed ludicrous; today it is assumed that it will be filled without question and not only dramatically but beautifully as well. Extensive use is being made in this type of picture of filters which give a dark sky. A deep yellow filter, more preferably a light red or orange-red, is indispensable in such work; by darkening the sky, industrial scenes that include a good portion of the sky are brought into striking prominence and relief, making all the difference between the ordinary and the unusual. A medium yellow filter during the day, or no filter at all in late afternoon when the sunlight tends to yellow, will render clouds in approximately the relation that we see them with the naked eye. Such pictures have a definite atmosphere about them that is so desirable in depicting certain moods. Shadow patterns cast on a factory wall frequently offer interesting material. Good composition is important, and especial care must be taken in this regard when pointing the camera at an angle to get a "worm's-eye" view. Just placing the camera at an unusual angle is not all there is to "angle photography." See this Department, October, 1935, for hints on this subject.

Study the work of the best industrial and



An interesting example of "New Fields to Conquer"

$100 IN PRIZES

FOR AMATEUR PHOTOGRAPHS ON SCIENTIFIC AND ALLIED SUBJECTS

HERE is a real chance for advanced amateur photographers to achieve international recognition of their skill. Scientific American offers $100.00 in cash prizes for the three photographs, submitted according to the following rules, which the Judges decide are the best. Furthermore, there will be ten Honorable Mention awards, each of a one-year subscription to Scientific American. The publishers also reserve the right to purchase, at regular rates, any non-winning photographs submitted in this contest.

Read the rules carefully and then go to work. But please be sure that your entries comply with all the rules as the Judges cannot be held responsible for entries which do not.

RULES OF THE CONTEST:

1. Photographs entered in this contest must depict some phase of science, industry, engineering, aviation, or kindred subject.
2. Entries will be judged on the basis of pictorial value and photographic technique. The decision of the Judges will be final. In case of a tie for any prize, duplicate prizes will be awarded to the tying contestants.
3. All of the photographic work involved in producing prints for this contest must be done by the contestant.
4. Photographs submitted must be printed in black and white on glossy paper and must be mounted.
5. Prints must not be under 7 inches or over 14 inches in their longest dimension. Mounts must not be larger than 14 by 17 inches.
6. Photographs must be submitted by first class mail, with sufficient cardboard included in the package to protect the print.
7. Each entry must have the following information written on the back of the mount:

   Name and address of contestant;
   Camera and lens equipment used;
   Size and emulsion of negative;
   Filter used, if any;
   Diaphragm opening and time of exposure;
   Month, time of day, and quality of light;
   If indoor, contrast of paper used;
   Developers used for negative and paper;
   Additional aids employed.

8. Prize-winning photographs will become the property of Scientific American, to be used in any manner at the discretion of the publisher.
9. Scientific American reserves the right to purchase, at regular rates, any non-winning entry.
10. Non-winning entries will be returned only if postage is included when the prints are submitted.
11. No entries will be considered from professional or commercial photographers.
12. All entries in this contest must be in the hands of the Judges by June 20, 1936. The results will be announced in our issue dated September, 1936.
13. This contest is open to all amateur photographers who are not in the employ of Scientific American.

PRIZES:

First Prize, $50.
Second Prize, $30.
Third Prize, $20.

Ten Honorable Mentions, each to receive a One-Year Subscription to Scientific American.

The Board of Judges of this contest will be announced in a subsequent issue.

Address all entries to:
Photograph Contest Editor
SCIENTIFIC AMERICAN
24 West 40th Street, New York City

scientific photographers—those who seek the pictorial rather than the merely "record" type of picture. Their pictures are worth careful study; they will help you in your own attempts.

FOR PAPER NEGATIVES

A PAPER especially designed for use in the paper negative process has recently been introduced under the name Charcoal Black Grade F, also known as "Opaline Parchment . . Extra Thin." An instruction sheet is enclosed with every package giving four different methods of producing paper negatives, outlining each procedure to the making of the final print, in addition to a process by which a "parchment texture" effect is obtained. The paper, which is matt and unusually translucent, is notable for the fidelity with which it records fine detail.

PORTRAITURE "KINK"

IF your wife has been "crabbing" about your hobby of late or the young lady you take out Wednesday nights has not been as enthusiastic about your pictures as you would like, try winning her over by making

a portrait of her that is truly "different." It should be done by artificial light indoors and with blinds drawn so that no stray light streaks in to take the lighting out of your control. Have your background dark and unlighted so that no background detail will show in the negative. Black cloth will have to be used. Seat the subject a few feet away from the background. Get a piece of dull black cloth—the dull side of your focusing cloth, if you have one, will do the trick; you won't need one for focusing on this job for the room will be dark except for a single light, and that will be directed at the lady. Arrange the cloth around the subject's shoulders and bring it down in front for a "V" neck. The light must be concentrated, as in a spotlight, so that only the head, face, and neck are illuminated. A little spilling of light onto the cloth won't do any harm as the exposure will be very short. The resulting print, showing the only part of a portrait that we really want, should prove quite flattering and go a long way toward winning you the use of the clothes closet for developing purposes—or the equally coveted "date."

"QUINOLIN"

UNDER the name "Quinolin" a new prepared developer is made available to the camera worker who prefers to have his chemicals ready mixed so that all he has to do is add the necessary amount of water for dilution to working strength and in order to give volume. According to the manufacturers, this developer, employing a developing agent never before included in a prepared developer, "brings out the entire tonal range from deepest blacks to strongest highlights." It is said to last longer than the usual type of metol-hydroquinone formula and to give, by direct development and the use of chlorobromide papers, warm black and black-brown tones. Used with chloride and bromide papers, pure black and blue-black tones are said to be obtained. The developer may also be used for negatives.

NEW LENS SCREEN ELIMINATES GLARE

MISCHIEF-MAKING glare and busybody reflections that butt in where they're not wanted are summarily "given the gate" by one of the newest camera accessories. The device, called Pola-screen, consists of a transparent sheet of polarizing material containing a great number of minute, parallel, rod-like crystals, which is cemented between glass plates and is used in the same manner as a filter; that is, placed in a holder and slipped over the camera lens. Glare and reflections are eliminated by rotating the screen.

The new screen would seem to be the perfect answer to the photographer who has been troubled time and again by the oblique glare coming from certain polished surfaces and bothersome reflections that do not belong in the picture. In addition, the new device when used in "shooting" against a blue sky provides a dark sky; also, the Pola-screen helps to control the relative brightnesses of walls and roof in architectural pictures.

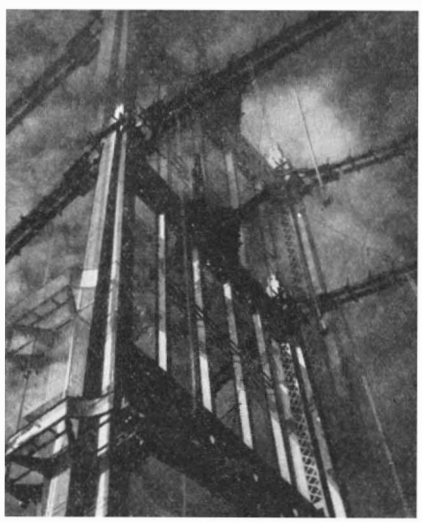
The distributors announce that the new device "is a practical application of the fact

that light rays normally vibrate in all directions at right angles to the ray itself but under some conditions become 'polarized,' meaning that all directions of vibration but one have stopped. This occurs in oblique reflection, and in the light coming from a clear blue sky."

They explain further that when the screen is rotated, "the direction of vibration of the transmitted light is rotated and at a certain position the polarized light is absorbed and thus cut out of the picture."

"GHOSTING"

GHOSTS are usually associated with things past. In the illustration below, based on our cover for the December issue, we present a ghost of things to come. Once



How that bridge grew!

the Brooklyn Bridge was something to talk about. Today we have the Triborough and the San Francisco bridges. Tomorrow . . . ?

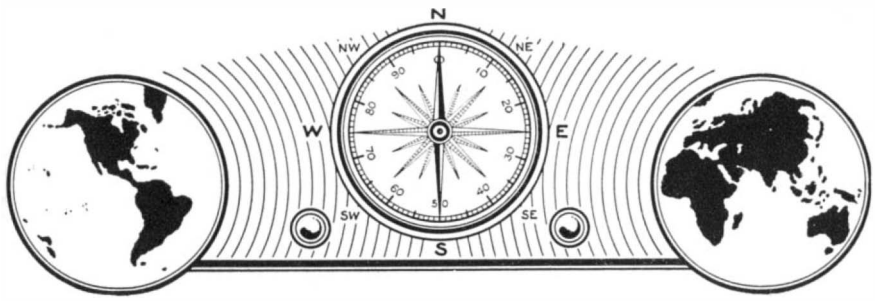
The print was made by giving the "ghost" bridge a brief exposure, moving the easel forward, and then giving full printing time.

DAYLIGHT LOADING TANK

PERMITTING loading of the tank in broad daylight and useful for a variety of sizes of roll films ranging from 1⅝ by 2½ inches up to and including 2½ by 4¼ inches, the Superplex Universal Developing Tank would seem to furnish the answer to the problems of the traveling photographer or the man without a darkroom.

Made of acid-proof Bakelite, its distributors claim for it the advantages that no oxidation of the developer is possible because of the lack of metal parts in the tank, no light can enter the tank after it has been loaded in broad daylight, and the film emulsion is carefully treated. After the spool is placed in the tank, the covering paper is drawn out, permitting automatic winding of the film on to spirals, only the actual film coming in contact with the developing solution.

What specific phases of advanced amateur photography do you want to see treated in this department? These columns are yours and you can help to make them better. Drop us a line and we will do our best to co-operate.—The Ed.



WORLD-WIDE RADIO

Conducted by M. L. MUHLEMAN*

Radio Noise Silencer

NATURAL static and man-made noise are the greatest drawbacks to radio communication. Millions of dollars have been spent in attempts to reduce these forms of interference to negligible quantities. This has been accomplished to a degree in broadcasting by using transmitters of such high power that the signals can over-ride the noise. In commercial communication the condition has been relieved somewhat by the use of directional antennas, controlled-angle radiation, volume compression, and by placing the receiving stations in locations free from man-made noise.

Little progress was made in attempts to eliminate the noise in the receiver. There appeared to be no solution to the problem.

A partial solution has now been advanced, and the system seems practical enough to warrant further investigation. It has the drawback of not being capable of eliminating all types of interference. Moreover, by reason of the nature of its functioning, it is apt to destroy the quality of a musical program spotted with certain types of noise interference. But the system will accomplish a great deal, nevertheless, and will find ready application to short-wave receivers wherein noise is particularly objectionable.

The device is the invention of James J. Lamb, Technical Editor of *QST* magazine. It employs two tubes which amplify and rectify the noise impulses to the exclusion of the signal. The voltages developed by the noise impulses are then used to silence the radio receiver.

The functioning of the device is based on the fact that average noise impulses, such as those created by an automobile ignition system, are widely separated and of short time duration. The ear is insensible to impulses so widely spaced and of such short duration, but through the processes of amplification in the receiver and reproduction of the sound from the loudspeaker, such impulses have their duration increased from around one thousandth of a second to as much as one hundredth of a second. Impulses having such duration are audible.

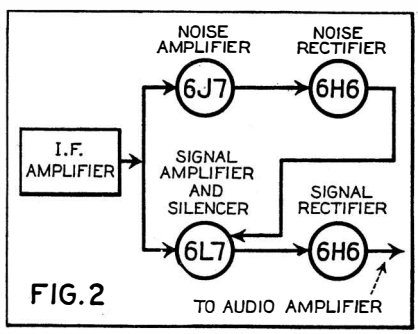


FIG. 2

The trick, then, is to catch the noise impulses before their duration is increased appreciably, and to use the voltages set up by these impulses to *punch holes of silence* in the received signal at the exact time-spaces where the noise impulses appear. That is, to wipe out both the noise impulses *and the signal* at these time-spaces. Just so long as the spaces of silence have the same short durations of the noise impulses they replace, the ear will be insensible to the interruptions and will hear the signal as a continuous sound.

The sketches of Figure 1 will serve to indicate what transpires. Sketch A shows the continuous signal which is maintained at a constant level by the automatic volume control in the receiver. The noise silencer is adjusted so that it will go into operation on any impulse having an amplitude greater than the signal level. There is shown superimposed on this signal a group of noise impulses, some of which have amplitudes less than the signal and some of which have amplitudes greater than the signal. Since it is necessary that the operation of the noise silencer shall not in any way affect the continuous signal, it is evident that it cannot cope with the noise impulses the peaks of which are below the signal level. However, it will go into operation on any impulse the peak of which is above the signal level and, for the instant the impulse is present, silence the receiver.

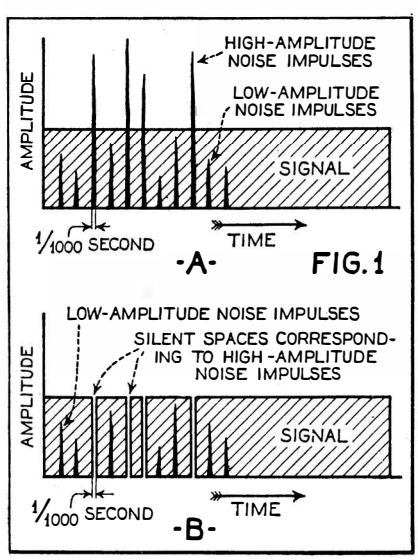


FIG. 1

*Editor *All-Wave Radio*

The result is shown in sketch B of Figure 1. It is seen that the small noise impulses are still present, but they are not particularly objectionable as the signal is able to override them. Note, however, that the strong noise impulses have been wiped out, and in their place are holes of silence.

The noise silencer is really nothing more than a quick-action automatic volume control system. It is shown in block diagram form in Figure 2, and is seen to consist of a 6J7 tube which amplifies the noise impulses and a 6H6 tube which rectifies the noise impulses and converts them into direct-current impulses, the voltages of which are negative in value. These two tubes are adjusted so that they do not function on the constant signal voltage.

Below these tubes are shown the 6L7 intermediate-frequency amplifier tube in the receiver and next to it the 6H6 second detector and automatic-volume control tube. Just as long as the signal is not accompanied by noise impulses greater in amplitude than that of the constant signal level, the signal passes through the 6L7 and 6H6 tubes where it is amplified and rectified in the usual manner. However, if a noise impulse appears, it sets the noise silencer into action. The impulse is first amplified by the 6J7 tube and then rectified in the circuit of the 6H6 tube. The resulting instantaneous negative voltage appearing in the output circuit of the 6H6 tube is fed to the Number 3 grid of the 6L7 intermediate-frequency amplifier tube in the receiver. The effect of this negative voltage is to bias the 6L7 tube to cut-off, at which point it no longer functions as an amplifier. At that instant, then, the receiver is silenced. As soon as the original noise impulse ceases, the negative voltage in the output of the 6H6 noise rectifier tube disappears and as a result the 6L7 tube is returned to its original condition of maximum amplification.

Thus, for every large noise impulse, a "bullet" of negative voltage is fired on to the Number 3 grid of the 6L7 tube and the receiver is silenced. At all other times the receiver functions in its normal manner.

Volume Expansion

MUCH of the naturalness of reproduced radio orchestral music is lost if the original volume range is restricted or compressed. The feeling of musical depth is lost, and the proper relation of fundamental frequencies and overtones is not obtained if the volume peaks of the original rendition are appreciably reduced.

A symphony orchestra will have a volume range in the neighborhood of 70 decibels when playing, say, certain portions of Rimsky-Korsakow's "Scheherezade." That is, the range of sound volume, from the softest to the loudest passage, will be 70 decibels.

It has not been possible to reproduce by phonograph or over the radio any such volume range. A phonograph record has a volume range no greater than 45 decibels, and possibly as much as 5 decibels of this range are made unusable by needle scratch. The average broadcast transmitter has a volume range of only 40 decibels. Any attempt to increase this range either places the soft musical passages below the noise level at the receiver, or places the loud passages beyond the safe limits of carrier modulation.

But means have been devised for opening up a compressed volume range at the point of reproduction. The RCA Manufacturing Company have incorporated a "volume expander" in a new radio-phonograph combination. The expander is not used with the radio, but produces a volume range of 65 decibels on recorded music.

This is accomplished by using a variable-gain audio-frequency amplifier in such a manner that the greater the volume of the music, the greater the amplification. The result is that soft musical passages retain about the same relative volume level they have on the record, but the louder passages

A radio volume expander

are considerably increased in volume level. Thus, a musical passage having a volume-level value on the record of 40 decibels is expanded so that the actual relative volume-level at the loudspeaker is slightly in excess of 60 decibels. Thus, the 20 decibels or so lost in a recording of the original orchestration are put back by the volume expander.

Volume expansion has also been added to the radio receiver. The Crosley Radio Corporation have developed a device called the Auto-Expressionator which is being used in a few of their latest receiver models.

The Auto-Expressionator is also a volume expander, but instead of employing a variable-gain amplifier, two small bulbs are used; these bulbs have special filaments, the resistances of which increase with an increase in current flow.

There are two paths through which the audio-frequency currents may flow. The loudspeaker is connected in the circuit of one of these paths, and the Auto-Expressionator bulbs are in the other path. At low volumes the signal divides equally between the two paths, causing the loudspeaker to operate at only half volume. As the volume of the signal increases, the Auto-Expressionator or bulb path becomes more and more restricted, causing more and more audio-frequency current to be diverted and to flow through the loudspeaker, thus resulting in a volume increase greater in proportion than that supplied by the receiver.

The method of operation of the Auto-Expressionator is somewhat similar in principle to that of the Wheatstone bridge. It consists of a division of the current into two paths. The amount of current flowing in each path is dependent upon the amount of resistance present. Since the filaments of the Auto-Expressionator bulbs vary in their resistance values with a change in signal-current flow (volume), the division of current flowing in each path is altered in accordance with changes in signal volume.

The Auto-Expressionator operates continuously during the time it is turned on, even though the bulbs may not be illuminated. The functioning is immediate and automatic.

THE SCIENTIFIC AMERICAN DIGEST

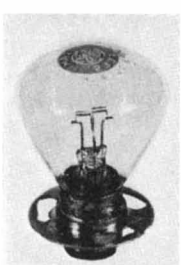
(*Continued from page* 213)

tained. Even hides, thick or thin, always work up most satisfactorily.

Precision construction features equipment of this kind. Every part must be finished with microscopic care. The roll must be rigid, and there can be no play in the bearings. Even the least wear in the bearings, which support the roll, would result in spoiled or uneven hides. The Timken bearings used in this machine can be adjusted to the hair-splitting degree of accuracy necessary to insure smooth, friction-free operation at high speed, and to give absolute steadiness and long life under operating conditions.

New "Bar-filament" Auto Bulb

FOR a new type of headlight which is standard on many of the 1936 cars, the Incandescent Lamp Department of the General Electric Company recently developed a new headlight bulb which differs considerably from other headlight bulbs in that



the filaments, instead of being V-shaped and placed one above the other, are in bar form and are located side by side with one slightly above the other.

In switching from the one filament to the other, both headlight beams are simultaneously shifted to the right and are lowered somewhat. This provides illumination of higher intensity along the right hand side of the road and at the same time gives relief to the oncoming driver.

The new bulb is equipped with the now familiar pre-focused base. The contacts, however, are so positioned that they will line up only in headlamps that have been especially designed for the new bulb.

Medicines Will Taste Better

BETTER-TASTING medicines will apparently be one result of changes in the National Formulary, which might be called an official recipe book for pharmacists, says *Science Service.* The changes embodied in the sixth revision of this volume which becomes official on June 1, 1936, are explained by Dr. Adley B. Nichols, secretary of the National Formulary committee on revision.

The National Formulary—known as N.F. for short—is a companion to that other legal standard for drugs in the United States, the U. S. Pharmacopoeia. The latter includes drugs and remedies of proven efficacy, regardless of whether they are widely used or seldom used. Products are included in the N.F., on the other hand, on the basis of how generally they are used.

In the present revision 321 items were dropped from the book because a survey of over a hundred thousand prescriptions, collected from all parts of the country, showed that these items were not used in actual practice. A total of 233 new items were admitted.

Six glandular products were admitted—corpus luteum, ovary, ovarian residue, anterior pituitary, whole pituitary, and suprarenal.

Salty-tasting medicines such as the bromides should taste better because syrup of raspberry is the official "vehicle" for these preparations. The resulting effect is like adding a pinch of salt to bring out the flavor of the syrup.

Syrup of acacia is another new vehicle which makes disagreeable medicines pleasant to take because the colloidal action of the acacia keeps the medicine from coming in contact with the taste buds on the tongue.

Syrup of cherry is another new addition which has been widely acclaimed.

"Its specific value lies in its fruity tartness which makes it a delightful mask for sour products such as the diluted acids, where the acid almost enhances the taste rather than destroys it," Dr. Nichols says.

For a change, pharmacists are advised to use syrup of thyme which has "a markedly different taste."

Tame Cats Gone Wild Down Under

THE cat family, which is carnivorous, had never penetrated Australia until the advent of the white man, less than 150 years ago. That is why Australia's native fauna, which for the most part is herbivorous, has survived from a pre-carnivorous age.

Now, however, thousands of domesticated cats, gone wild, are waging ferocious war on the native bird life of the uninhabited or sparsely populated interior, and, in some districts, wiping it out altogether.

"On a trip of 1600 miles from north Queensland down to Lake Eyre," Ion Idriess, the author, remarked, "I saw countless thousands upon thousands of these cats. Apparently they have been breeding over a score of years, and have grown much larger than the ordinary domestic cat."

Idriess reports that at one water hole he saw 50 cats fighting and tearing one another to pieces while hundreds more snarled down from the trees. Cockatoos and parrots seem to be surviving because they can defend themselves, but other native birds are being decimated.—*Australian Press Bureau.*

Electricity Purifies Milk

PASTEURIZATION has been supplanted by electrical treatment in the plant of Foremost Dairies, Birmingham, Alabama, says *Food Industries.* Passing upward through a vertical box-like vessel with carbon electrodes on opposite sides, the milk is subjected to 215 amperes at 220 volts. The milk itself conducts the electricity from one electrode to the other and the minerals in it offer sufficient resistance

to raise the temperature to 165 degrees. The milk is five seconds in passing between the electrodes and is 15 seconds in the detention period, making a 20-second exposure to the high temperature.

This method is said to give highly accurate control, the milk being delivered by a constant-speed pump through a constant electrical discharge. Another advantage attributed to the process is that the milk does not contact any hot equipment, so that there is no oxidation or deposit of milkstone on the utensils. Furthermore, it is said, the method does not alter the flavor, caramelize the sugar, change the color, or break down any elements of the milk.

The equipment handles 600 gallons an hour at a cost of approximately 45 cents per hour for electricity.—*A. E. B.*

RAILROAD SAFETY

TRAINS on the 800 railroads of the United States, operating over a total of 420,000 miles of track in 1935, carried human beings an aggregate of 18,400,000,000 miles without a single passenger losing his life through a passenger train accident.

Chickens Take Submarine Rides to Aid Science

A "CHICKEN-SUBMARINE" is Cornell University's latest contribution as a tool for scientific research. This little craft has been constructed by Dr. H. H. Dukes, professor of veterinary physiology, in his experiments in measuring metabolic rate at different temperatures. Not only have several big mother hens been induced to take long voyages in it, but they have proved to be very good sailors.

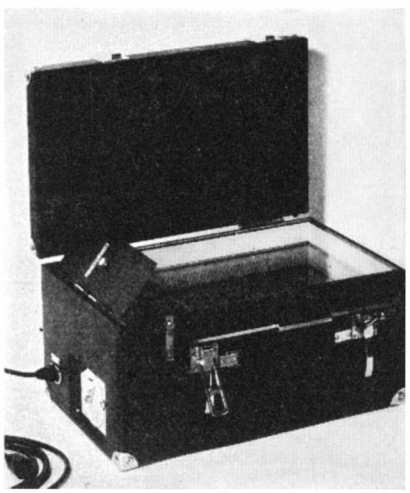
The "ship" is not only as completely air conditioned with purified air as a modern house, but it has a glass window in the side through which, when the little lid is raised, the hen may view with wonder the marine marvels to be found in a barrel of water. The chicken, when inside, is mounted upon a movable platform by which her slightest movement is recorded upon a smoked paper graph outside. Contrary to what might be expected, the chickens remain surprisingly calm and sleep most of the time in the night-like darkness of the submerged submarine.

Eight or ten hens work in shifts during the time the apparatus is in use. Each bird remains submerged from 14 to 18 hours, during which time she is subjected to varying degrees of temperature, corresponding to all the seasons. By starting with ice water and gradually raising the temperature to what would be summer heat, the hen can be observed under all conditions of weather. Though human beings under such a variety of temperatures would be uncomfortable, the chicken, says Dr. Dukes, is quite comfortable.

The real object of the experiment is, however, to measure accurately the metabolic rate of the hen, or the amount of fuel burned by her body under different conditions of environmental temperature. The gases given off by the body are trapped by means of the air-conditioning system, and are measured accurately. By this means Dr. Dukes will be able to determine the amount of food necessary to maintain the hen efficiently, and from this he hopes to be able to ascertain whether it is cheaper for the chicken farmer to heat his chicken houses or feed the birds more during the cold winter months.—*Science Service.*

Photo Copying Device

ONE of the latest developments in photo copying methods is the new portable, electrical Copyst, which makes prints similar to photostats but considerably less expensive. It reproduces facsimile copies of anything, whether written, drawn, stamped, or printed, whether loose or bound in a book, whether transparent or opaque.



Self-contained copying unit

The apparatus is a simple photo-printer compactly built into a box carrying all the equipment necessary. It comes in several sizes and can be operated by an inexperienced clerk in ordinary office daylight without the use of a dark room. The process uses a photographic paper of very low general sensitivity.

Inside the box there are no lenses or prisms, the copies being made of a size equal to the original by contact printing or reflected light. The sensitized paper is cut from a roll and mounted in a holder in the top of the box. The copy to be reproduced is placed also in the holder against the sensitized paper. A small portable electric dryer is included with the equipment and completes the process.

Duck Inventory With Hundreds Making Counts

THE second annual inventory of migratory waterfowl spending the winter in the United States, which was completed in January, was extraordinary in the completeness of its organization. The inventory, under the direction of the Bureau of Biological Survey, was made after long planning and with the largest number of qualified observers ever assembled. The country-wide census was completed in just two days.

Eight regional directors of the Division of Game Management assigned estimators to survey definite areas by ground, water, or air. In addition to the regular field per-

sonnel of the Survey (United States Game Management Agents, District Agents, Refuge Managers and Superintendents, Wildlife Technicians, and others), observers were augmented by state game wardens, personnel from the Forest Service, the Soil Conservation Service, the Bureau of Public Roads, state police officers, observers from certain state colleges, and volunteer observers from the regular list of the Survey, and from the membership of the National Association of Audubon Societies.

Many observers operated by automobile. The "navy" of patrol boats of the Biological Survey was greatly enlarged by patrol craft of state game commissions, by boats of the Bureau of Navigation and Steamboat Inspection, patrol vessels of the Coast Guard, and by many privately owned power boats.

The Navy Department, the Coast Guard, and the Connecticut National Guard furnished land planes or seaplanes, and a few interested civilians contributed the use of aircraft, so that all coastal areas were surveyed from the air as well as from the land or water. The War Department furnished a blimp, the *TC-13*, stationed at Moffet Field, California. The blimp *Enterprise* surveyed the Potomac River from Washington, D. C., to Point Lookout.

Frederick C. Lincoln, biologist of the Survey who directed the inventory, had eight field armies and a couple of navies thrown in for good measure.

Regional Director W. M. Rush, at Portland, Ore., reported 106 observers for his region, including men from his own office, the Forest Service, three State Game Departments, a state college, and several volunteer operators, not to mention automobiles, power boats, seaplanes, and the *TC-13*.

Regional Director Bertrand E. Smith, at Portland, Maine, had about an equal number of observers, with Coast Guard Patrol boats, cutters, and seaplanes from Cape May, New Jersey; Salem, Massachusetts; from the Navy airports on Long Island, New York and Chatham, Massachusetts; and from the air service of the Connecticut National Guard.

These "sample" forces were equalled or beaten in numbers and variety of craft by a number of other districts. Two biologists of the Survey worked in the waterfowl areas of Mexico. When all reports have been analyzed, the Bureau hopes to have available a reasonably accurate estimate of the continental supply of waterfowl, most of which will shortly be starting the long flight to their nesting grounds.

Stretchable Lacquer Finish

A "STRETCHABLE" lacquer finish, claimed to rival the flexibility and distensibility of rubber itself, is noted in *The Rubber Age*. Tests conducted on this new lacquer showed that when applied on a piece of live rubber, and both stretched to the limit, the finish remained intact.—*A. E. B.*

Bad News for Unscientific "Collectors"

BY a resolution of the State Legislature of Nebraska, police powers over sites of archeological and paleontological interest have been conferred, says the magazine *Nature*, on the State Geological Survey, which will enable that service to control the future collection of antiquities and fossil bones, for which the state is widely known as a favorable locality. Although the efforts of the National Research Council have done much to make widely known among the people of the United States the desirability of preserving intact their monuments of antiquity, up to the present only a few of the states have taken legislative action to protect them; and should the measures adopted in Nebraska prove effective, it is anticipated that other states will follow this example before long.

As recent investigations have shown, Nebraska and the neighboring states of the southwest are rich in relics of early man and of the extinct fauna with which, it would appear, early man was associated in this part of America; but this wealth of material has proved an irresistible attraction to the amateur collector and the curio hunter, with the result that much important scientific evidence has been lost or destroyed by the removal of specimens from their stratigraphical context without adequate record, or indeed, in many instances, with no record at all.

Some indications of the extent of the loss that science has suffered in this way is afforded by the references to important archeological specimens in private hands scattered throughout the records made by Prof. E. B. Renaud's archeological surveys of Colorado and adjacent territories. It has been specifically stated on behalf of the Geological Survey that there is no intention to restrict duly accredited scientific research. [See also page 177.—*Ed.*]

Belgian National Park More Than Doubled in Size

BELGIUM'S great national park in the heart of Africa, where dwell gorillas and many other strange and rare beasts and birds, has been more than doubled in size by recent governmental decree. Its total area now comprises nearly 857,000 hectares, or almost 2,500,000 acres.

The new extension includes Lake Edward and a number of smaller lakes, a large area in primitive equatorial forest, and Mount Ruwenzori, where perpetual snow lies on the equator.—*Science Service.*

Devilfish, Barnacles, Seaweed Eaten by Indians

PEOPLE will eat queer things, if they have to—or if they happen to like them. The diet of the Pomo Indians of the California coast once included such marine delicacies as devilfish, barnacles, sea-urchins, sea-anemones, sea-cucumbers, and various kinds of seaweed, besides such more familiar items as lobsters, crabs, mussels, and abalone, according to *Science Service.*

Altogether, 15 seashore animal species and three kinds of marine plants were eaten by these Indians, Omer C. Stewart of the University of California has learned. His investigations included questioning aged members of the tribe, and digging in the refuse mounds left by many generations of feasters.

CURRENT BULLETIN BRIEFS

(Bulletins listed as being obtainable through Scientific American can be supplied only by mail)

WHERE TO BUY, RENT, AND BORROW SILENT AND SOUND-ON FILM, 16 MM. FILMS, is a 100-page booklet that will be valuable to educational and other institutions where motion picture equipment is available. *Write for Bulletin 436M to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

TEN FACTS ON TECHNOLOGY AND EMPLOYMENT is a notable attempt to prove that machinery is a creator of jobs rather than a destroyer of employment opportunities. Ten pages of sound reasoning. *Write for Bulletin 436L to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

EVIDENCES OF RECOVERY is a single sheet graph 16 x 15 inches showing business activity, construction volume, and wholesale prices of various commodities from January 1932 to December 1935, giving a comprehensive picture of the industrial situation in the United States. *Write for Bulletin 436E to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

LESSONS FROM DUST EXPLOSIONS is an illustrated pamphlet of 78 pages, plus an appendix, which surveys the record of dust explosions during the past four years. It is of exceptional value to all those interested in plant design and management. *Write for Bulletin 436F to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

A RUBBER PLANTATION IN NEW JERSEY is a nicely bound little booklet telling of the development of Thiokol, the first commercial synthetic rubber produced in the United States. The book gives some of the chemical background of the development and tells specifically of the uses which it finds in industry. *Write for Bulletin 436B to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

THE PROPER USE OF EXPOSURE METERS, by Joseph M. Bing, F. R. P. S., is a small, compact pamphlet of 12 pages which gives pertinent data on the subject. It includes a practical list of speed values in the Scheiner scale. *Write for Bulletin 436A to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

PROGRAM SOUND SYSTEM describes a newly developed public address system designed for use in schools, hospitals, hotels, department stores, and so on, where it is desirable to keep a large organization in constant touch with some one particular department or office. *Write for Bulletin 436D to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

TELEPHONE ALMANAC FOR 1936 is an attractive little booklet, prepared in the style of the old-fashioned but familiar almanac, which is particularly concerned with the development and present status of telephone communication. *Distributed upon the request of telephone subscribers through the local telephone companies of the Bell System.—Gratis.*

THE MODERN OFFICE BUILDING is a brief pamphlet describing the windowless office building—construction, air conditioning, lighting, furnishings, and so on—of the organization which distributes it. *Hershey Chocolate Corporation, Hershey, Pa.—Gratis.*

A GUIDE BOOK FOR WILLIAMSBURG, VIRGINIA, is a well presented little booklet of 48 pages, giving brief yet comprehensive descriptions of all of the points of interest in the historical town of Williamsburg. It also reviews the history of the community and presents a useful guide map. *Colonial Williamsburg, Inc., Williamsburg, Virginia. —25 cents.*

MICROSCOPE EQUIPMENT FOR THE AMATEUR is an illustrated leaflet describing all types of microscopic equipment from the lowest price to the highest. *Write for Bulletin 436C to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

WINE MAKING AND BRANDY PLANTS is a handbook of information relative to the present status of the wine industry and of fruit spirit distillation, designed for distribution to field engineers in this particular industry. *Write for Bulletin 436G to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

CONTROL is a message to the transportation industry, concerned specifically with the brakes used on present-day automobiles. It surveys critically the service to which motor car brakes are subjected and points out solutions to some of the problems. *Write for Bulletin 436K to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

NATIONAL PARKS OF CANADA, ANNUAL REPORT OF THE COMMISSIONER OF NATIONAL PARKS, is a beautifully presented booklet of 64 pages, illustrated with several photographs, telling of the work accomplished by the Commission during the fiscal year ending March 1935. *Department of Interior, Ottawa, Canada.—Gratis.*

NUTRITIONAL CHARTS is a 28-page booklet giving vitamin data and information on mineral nutriments, composition of common fruits, cereals, nuts, poultry and dairy products, and miscellaneous foods. For medical, dental, dietetic, and food specialists only. *H. J. Heinz Company, N. S., Pittsburgh, Pa. —Gratis.*

WINDSTORMS, THEIR CAUSES AND EFFECTS, is a survey designed for use by special insurance agents as a desk-reference pamphlet, but will be of value to anyone who is interested in the destructive effects

of windstorms. The booklet is illustrated with several striking photographs. *Write for Bulletin 436H to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

SOME CHARACTERISTIC FIRES IN FIRE RESISTIVE BUILDINGS is a selection of reports and illustrations from the "Quarterly" of the National Fire Protective Association. *Write for Bulletin 436I to Scientific American, 24 West 40th Street, New York City. 3-cent stamp.*

BREWING INDUSTRY, PRESENT CONDITION AND PROSPECTS, is a compilation of material relative to brewing in the United States as it is today. *Write for Bulletin 436J to Scientific American, 24 West 40th Street, New York City.—3-cent stamp.*

TRISECTING THE IMPOSSIBLE

(*Continued from page* 191)

equation are said to be rational if they can be expressed without the use of radical signs. By way of illustration, 3, $\frac{a+b}{c\times d}$, $\sqrt{d^2}=d$, and the root of $ax+b=0$, are all rational; whereas $\sqrt{2}$, $\frac{a+\sqrt{b}}{\sqrt[3]{c}}$ and the roots of $x^2-3x+1=0$ are all irrational. All the square roots which we have indicated so far have been real square roots, the radical operating on a positive number. A number such as $\sqrt{-3}$ *is said* to be an imaginary number, and $2+\sqrt{-5}$ is called a complex number. These latter are not included in the usual number system of real numbers.

With this understanding of the meaning of terms, we assert without proof[2] the very important theorem:

Theorem: By ruler and compasses it is possible to construct only those points whose coordinates are expressible in terms of the coordinates of the given points as functions involving a finite number of rational processes and extractions of real square roots, and all such points can be constructed.

By this theorem we see that, if we have given us the points (3,0), and (π,0) we can construct (2π,0) and (2π + 3,0) but we cannot construct the point ($\sqrt{-3}$,0).

The Trisection of An Arbitrary Angle: In the preceding theorem we have summarized what it is possible to do with ruler and compasses alone, the only tools allowed

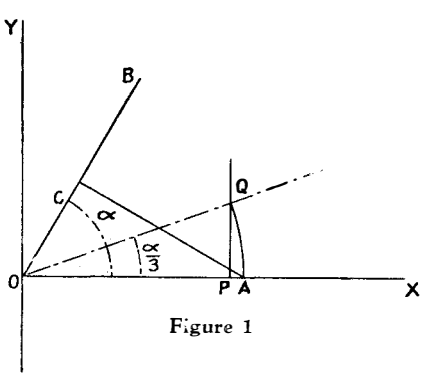


Figure 1

in Euclidean geometry. It remains for us to prove that there are angles which cannot be trisected, thereby proving that a construction to trisect an arbitrary angle is impossible.

In order to effect this proof, we shall have to express the trisection problem in terms of analytical geometry. Let us suppose, therefore, that angle *AOB*, see Figure 1, is the angle to be trisected. Let us choose *OA* to be the unit of length along the *X*-axis. Construct *AC* perpendicular to *OB*. By the definition of the cosine of an angle (see any book on trigonometry) we have at once cosine of angle $AOB = OC/OA = OC$, since $OA = 1$

There is an important relation between the cosine of an angle and the cosine of one third the angle which will be found in any book on trigonometry, namely, $\cos.\ \alpha = 4\cos.\ (\alpha/3) - 3\cos.\ (\alpha/3)$, in which α is an arbitrary angle. If we multiply both sides of this equation by 2, and set $x = 2\cos.\ (\alpha/3)$, we obtain $x^3 - 3x - 2\cos.\ \alpha = 0$ by transferring all the terms to the same side of the equation. Provided we can solve this equation by ruler and compasses (that is, provided we can construct $x = 2\cos.\ \alpha/3)$, we can trisect angle α as follows: The construction, be what it may, will yield us the point $(2\cos.\ \alpha/3,\ 0) = P'$ on the *X*-axis, from which we can construct the point $(\cos.\ \alpha/3,\ 0)$ by bisecting *OP'*. Therefore, for the present we will assume that we have located a point *P* on the *X*-axis such that the distance *OP*, the distance from the origin to *P*, equals $\cos.\ \alpha/3$. Through *P* we draw a line parallel to *OY*, and with *OA* (= 1) as radius and *O* as center we describe an arc cutting the parallel through *P* at *Q*. By this construction we have $OA = OQ = 1$ and, therefore, from the definition of a cosine, we have constructed $\cos.\ POQ = OP/OQ = OP = \cos.\ (\alpha/3)$. Therefore angle *POQ* is one third of angle α, in this case angle *AOB*, which was an arbitrary angle, and so we can trisect an angle by using *P, if we can locate it.*

We shall now show that it is impossible to trisect a 60° angle with ruler and compasses alone. Every angle in an equilateral triangle is 60°, and a perpendicular from a vertex to the opposite side divides an equilateral triangle into two right triangles, from which it is easy to verify that the cosine of 60° is ½. Substituting this value for $\cos.\ \alpha$ in the equation in *x* previously obtained, we get (1) $x^3 - 3x - 1 = 0$, the critical equation of our study. Has this equation a rational root?

A *real* root of this equation may be represented as a point on the *X*-axis and if it is to be rational it must be either an integer (whole number) or a fraction (whose numerator and denominator we can assume, without loss of generality, have no common factors). Let us take it to be $x = a/b$, where *a* and *b* are integers having no common factor greater than unity. Substitution in (1) yields $\frac{a^3}{b^3} - \frac{3a}{b} - 1 = 0$. Multiplying through with b^2 and transposing two terms, yields $\frac{a^3}{b} = 3ab + b^2$ and the right side of this

[2]For a discussion of points constructible with a ruler alone, and with ruler and compasses only, see H. P. Hudson: "Ruler and Compasses" (1916).

equation is an integer, since a and b are both integers by assumption. This means that a^3/b is an integer, which can occur (1) if a and b have a common factor, or (2) if $b = \pm 1$. Since the former is contrary to hypothesis, then for a rational root to exist we must have b equal to either $+1$ or -1, which means that *the rational root, if it exists at all, is an integer and not a fraction.*

Denoting the left side of equation (1) by $f(x)$, and substituting the values x equal to -2, -1, 0, 1, and 2 respectively, we find

$$f(-2) = -3$$
$$f(-1) = 1$$
$$f(0) = -1$$
$$f(1) = -3$$
$$f(2) = 1$$

and, noting the changes in sign of $f(x)$, we see that the three roots of (1) lie between -2 and -1, -1 and 0,1 and 2, respectively. Since a cubic can have only three roots we see that all three roots are real and must either be fractional or irrational. But we showed above that if (1) possesses a rational root it is an integer, and therefore the fractional possibility is eliminated and we can assert with certainty that *all the roots are irrational.*

Has (1) a root expressible in terms of rational numbers and real square roots; that is, has it a constructible root?

By utilizing various properties of radicals it can be shown[3] that *if a cubic equation possesses a root expressible in terms of rational numbers and real square roots, then it also possesses a root expressible as a rational number alone.* From this we conclude that if a constructible root of (1) existed, then there would exist also a rational root. Since we found that no rational root existed, we conclude further that *our equation has no root constructible by ruler and compasses, and we cannot trisect a 60° angle with these tools alone.*

This proves conclusively that it is impossible to trisect an arbitrary angle with ruler and compasses only.[4]

SOME Other Impossible Constructions: In the foregoing we have demonstrated that it is impossible to trisect a 60° angle, which implies, of course, that we cannot construct a 20° angle with ruler and compasses alone. A little further thought will show that a 40° angle is also one of those which cannot be constructed, for if we could construct a 40° angle we could construct the 20° one by bisecting it. Therefore, it is clear that *a regular polygon of nine sides cannot be constructed by ruler and compasses,* since the angle at the center subtended by a side is 360°/9, or 40°.

By utilizing certain trigonometric relations it can be shown[5] that the construction of a regular polygon of seven sides depends on the equation $x^3 + x^2 - 2x - 1 = 0$. By following through the very same procedure as above, step by step, we find that this equation has no rational root and, indeed, no root expressible in terms of rational numbers and real square roots. Consequently, *we cannot construct a regular polygon of seven sides with ruler and compasses alone.*

As a concluding demonstration we shall give a construction which trisects an arbitrary angle, and is typical of many of those which afford "news" from time to time, in that it involves a simple step which is, however, *not in accord with the rules of the game.* To begin, we assume that the problem has been solved, and that the line OT (Figure 2) is such that angle TOB = half angle

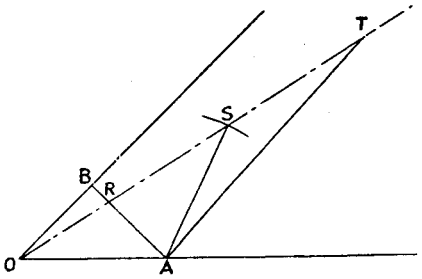


Figure 2

TOA. From any point A on one arm of the angle we draw a parallel and a perpendicular to the other arm. Describing a circle about A, with radius OA, we locate S on the trisecting line such that $AS = OA$. From the diagram we easily verify the following relations: angle AOS=angle ASO=angle SAT+angle STA and angle AOS= 2 angle TOB=2 angle STA. Consequently angle STA=angle SAT, giving ST=SA. Moreover, angle SAR=angle SRA, complements of equal angles. Consequently SA=SR, so that TR=2OA. This gives us the construction: Choose any point A, on either arm of the given angle, and draw a line parallel and a line perpendicular to the other arm. Now, with one end of the ruler at O, turn the edge until the intercept between the perpendicular and the parallel equals 2OA. This requires *measuring* (that is, either a scale or a sliding length equal to 2OA on the ruler) *and we are not permitted to measure with a ruler in plane geometry.* Our ruler is to be a straight-edge with which to construct straight lines—that is all. This construction is simple, interesting (and may be useful) but, like all the rest, it does not obey the rules of the problem.

To attempt to discover such a solution is a waste of time and effort for, as we have shown, it is insoluble.

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[3] See L. E. Dickson: "On the Trisection of An Angle," *Amer. Math. Monthly,* Vol. 21 (1914), and a similar article by the same author in *Mathematics Teacher,* Volume 14 (1921).

[4] We are able to trisect certain angles, for example 180°. In these cases the equation which corresponds will be found to have a rational root. For 180° we have *cos.* 180= -1, giving the equation $x^3 - 3x + 2 = 0$, which has a root $x_1 = 1$.

[5] See L. E. Dickson, "On the Trisection of An Angle," referred to above.

Books SELECTED BY THE EDITORS

OUTPOSTS OF SCIENCE

By Bernard Jaffe

POPULAR books about science appear with alarming frequency, but occasionally there comes one having outstanding merit and longer lasting value. "Outposts of Science" is, we think, such a work. It has been chosen as the Scientific Book of the Month. It could fairly be chosen the scientific book of the year. To it the author devoted four years, and the solid substance it contains—solid not in the sense of being difficult, but meaty rather than frothy—clearly reflects the careful preparation it received. His method of presentation enhances the interest of his treatment. The accounts of each science are linked up closely with its outstanding living personalities. Thus we have the following personality-linked chapters: *Genetics*, Morgan; *Anthropology*, Hrdlicka; *Physical Disease*, Welch; *Cancer*, Slye; *Glands*, Abel; *Mental Diseases*, Meyer; *Vitamins*, McCollum; *Insects*, Howard; *Matter*, Millikan; *Radiation*, Compton; *Astrophysics*, Hale; *Weather*, Abbot and Douglass; *Galaxies*, Hubble and Humason. There are 516 pages of superlative reading—authentic, up-to-the-minute information in each of the sciences named. In style this book is crisp, lucid, unaffected—never "dramatic" or sensational. In preparing it the author visited 50 of the most important research laboratories in the country.—$3.95 postpaid.—*A.G.I.*

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APRIL · 1936

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EWING HUTCHISON COMPANY
35 East Wacker Drive, Chicago, Ill.

BLANCHARD-NICHOLS-COLEMAN
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Published by MUNN & COMPANY, INC.
24-26 West 40th Street, New York

ORSON D. MUNN, President JOHN P. DAVIS, Treasurer I. SHELDON TILNEY, Secretary

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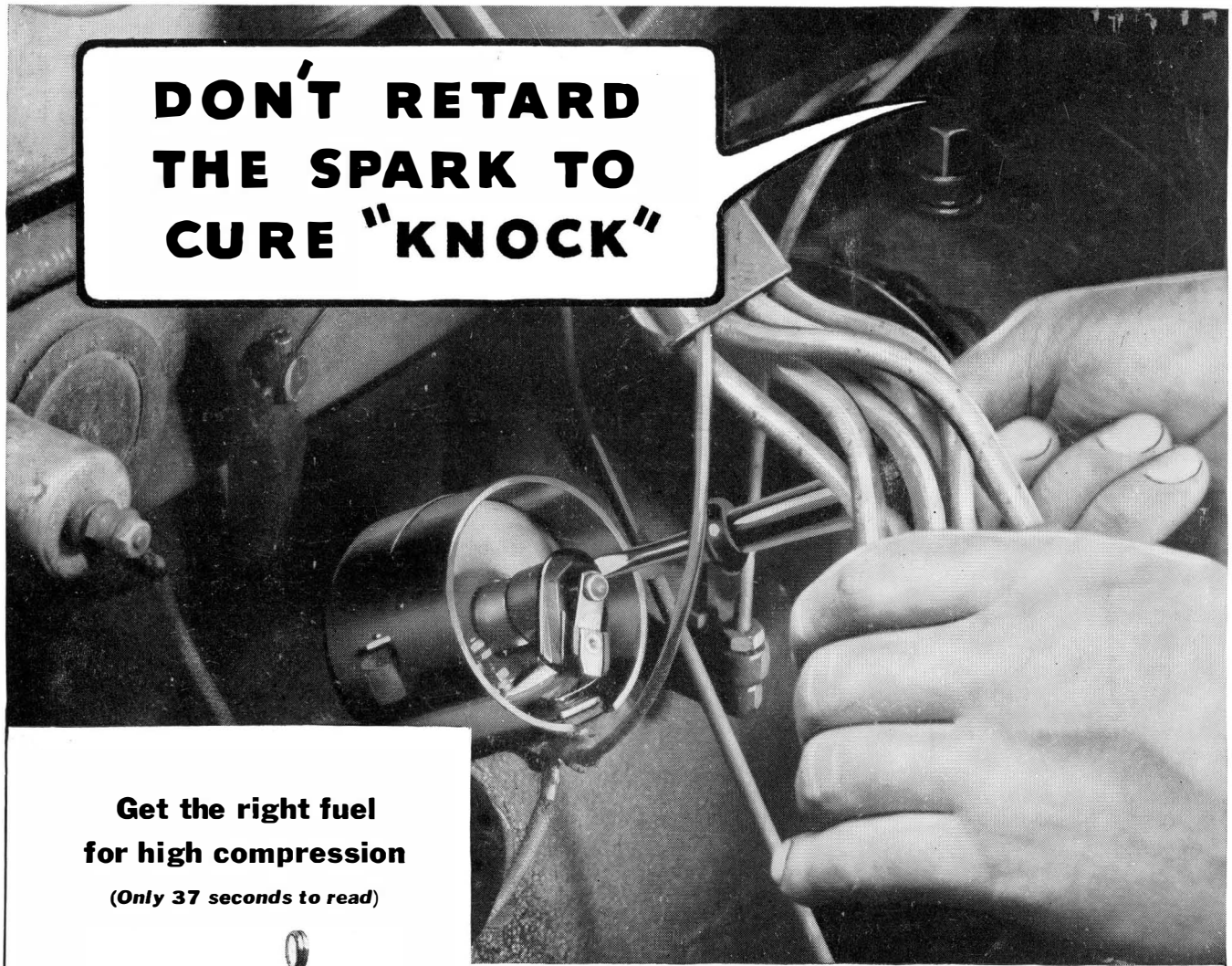

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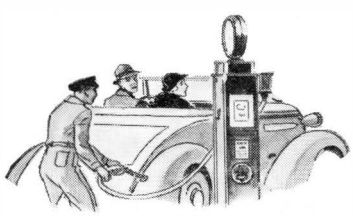

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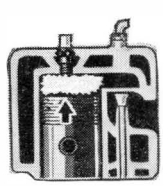
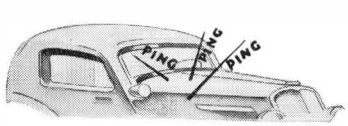


The more gasoline is compressed before it is "fired," the greater the power each cylinder develops.



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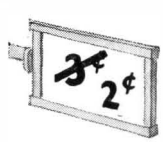

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