ASTRONOMY NUMBER

Sept.

Science and Invention

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FORMERLY
ELECTRICAL EXPERIMENTER

TOTAL ECLIPSE OF THE SUN SEPT. 10th

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Prof. William H. Pickering, Ph.D.; L.L.D.
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Professor Joseph Dunninger

Ray Cummings

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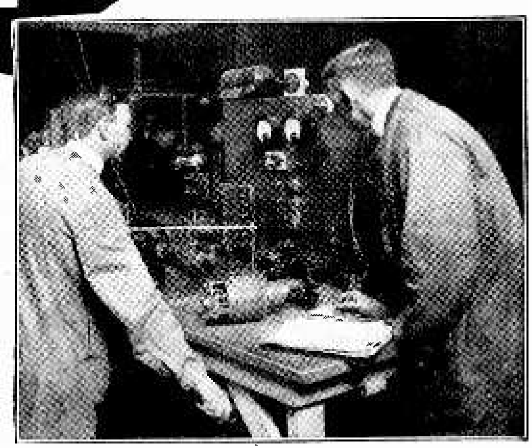

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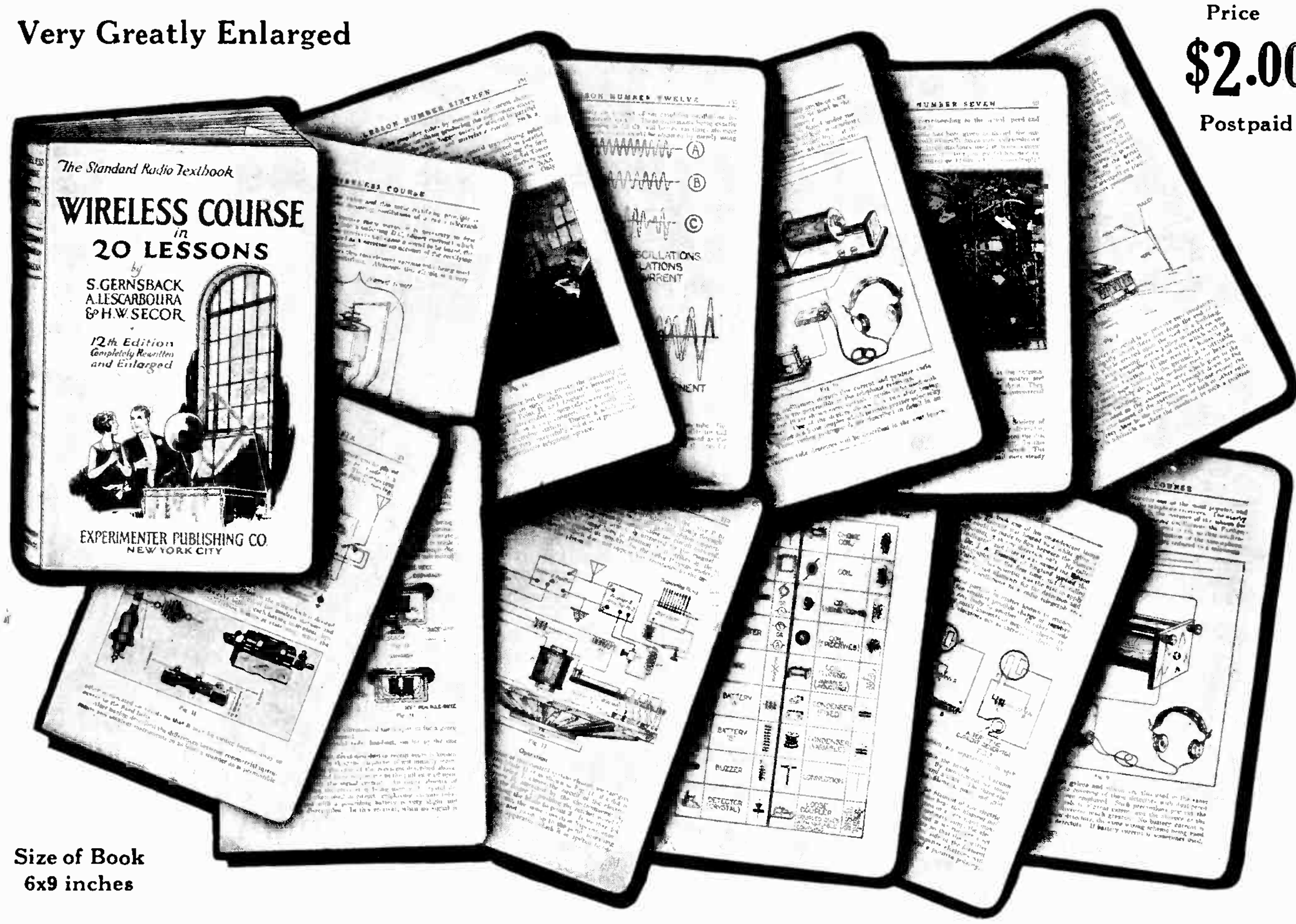

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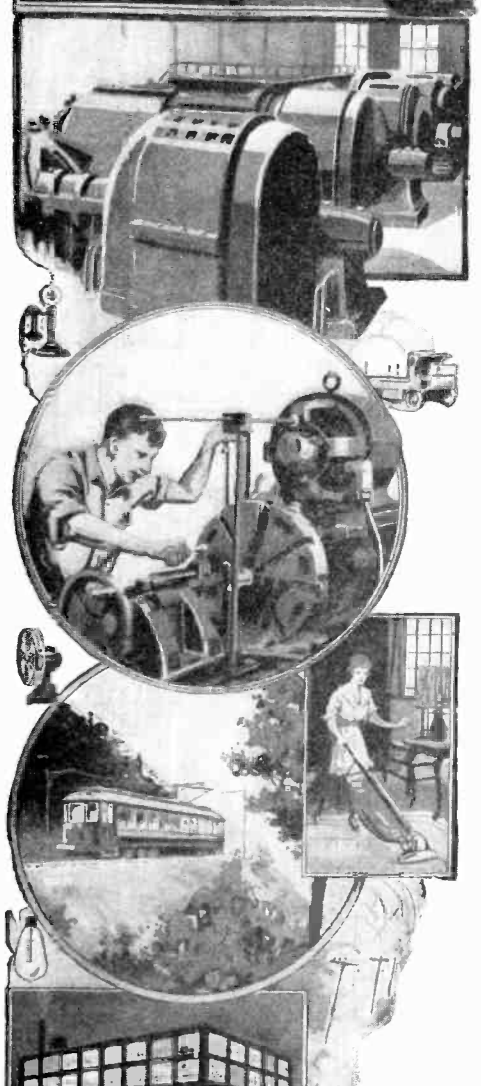

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SEPTEMBER
1923
No. 5

"Those Who Refuse to Go Beyond Fact Rarely Get As Far As Fact"--HUXLEY

What Good Is Astronomy?

THE average man, and there are millions like him, is apt to regard Astronomy as something unworthy of his attention. To the majority of people, even in this supposed enlightened age, the word Astronomy immediately suggests a shudder, and to most of the others it is a closed book with seven seals.

All these people may be compared to busy ants in an ant-hill who are so engrossed with their universe—the ant hill—that they never find time to see what goes on across the creek. To the ant, a distance of five miles is infinite. He is not even aware that such a thing as man, who prides himself as being the most glorious thing in creation, is in existence. Billions of ants never even see a man, and know nothing of his puny handwork.

The average man on the other hand, is either too lazy or too self-engrossed to lift his head to the stars and speculate as to what lies behind *his* mental creek. As for Astronomy, he is not at all interested in it, because it means nothing in dollars and cents to him. He knows there are such things as the sun, moon, and stars, and he is glad to leave well enough alone. If Astronomy could be expressed in dollars and cents, there would not be enough printing presses to print astronomical news. Unfortunately, so far, the money value of Astronomy has been practically nil to the public, but the time is coming when the average man will no longer see the stars as they are, but will see them as gold coins and valuable gems.

Let us therefore enumerate some of the actual everyday uses of Astronomy.

We might first mention that Astronomy has done away with a good deal of superstition that existed as late as 100 years ago. A solar eclipse four or five generations ago was a terrifying event and was looked upon as a vengeance of God, punishment of the devil, and what not. Since then, people know that the solar eclipse is caused by the moon getting between the earth and the sun. By our mathematics an eclipse can be predicted accurately to the day, hour, minute, and second, 100 or 1,000 years ahead, so that is a very natural affair to the astronomer. Astronomy, therefore, has been the cause which has delivered us from some of our superstitions.

We used to kill a lot of people sending them up in balloons that were filled with hydrogen. You will remember the many disasters of exploding air ships. All of this will be soon a thing of the past due to Astronomy, and particularly to spectrum analysis. The gas which is going to save us from death in dirigibles is called Helium. The gas is present in the sun in rather small quantities, and was unknown to earth until the spectroscope showed us its presence in the sun and now it has been found in quantities in the earth. In other words, Astronomy led us to the sun first and back to the earth in our practical quest of knowledge.

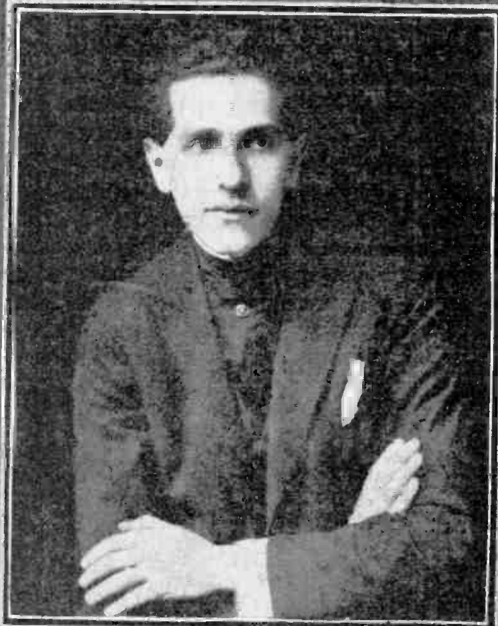
We have discovered several other gases in the sun which have not been found on earth as yet, but we know from experience that if a gas exists in the sun, it is reasonably sure that sooner or later it will be found on earth.

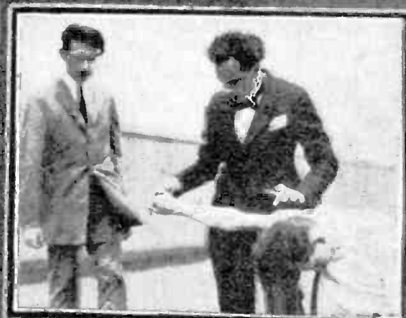
Our solar eclipse expeditions of what good are they? Why is so much money expended on them, just to look at the total eclipse for two or three minutes at an expense totaling tens of thousands of dollars? For one thing, there is the mysterious Corona which may be studied on the front cover of this magazine. We also know that in a total eclipse, spectrum analysis shows that there is present in this Corona, a gas termed "Coronium." So far it has not been put to any practical use because we have not been able to demonstrate its presence on earth, but we are getting there by degrees and once we have it, we shall no doubt put it to work making dollars and cents for someone. Also during a total eclipse, we expect to learn something about the mystery, about what keeps the sun hot. Good "Old Sol" has been giving out a tremendous volume of heat for at least a million years and possibly longer. So far, our puny efforts have not succeeded in unravelling the mystery as to just why the sun keeps hot. Its heat is estimated to run above 10,000 degrees C. No new fuel is added, still the titantic heat keeps up century after century, undiminished. Here is a secret that is worth, not thousands, but billions of dollars to the scientist who solves it. Suppose manufacturers could sell a little furnace or stove that would give out a tremendous heat for thousands of years, *at no cost whatsoever and without adding any fuel.* This is exactly what the sun does today, and some day we hope to wrest this secret from it, and if we do, it will be thanks to Astronomy.

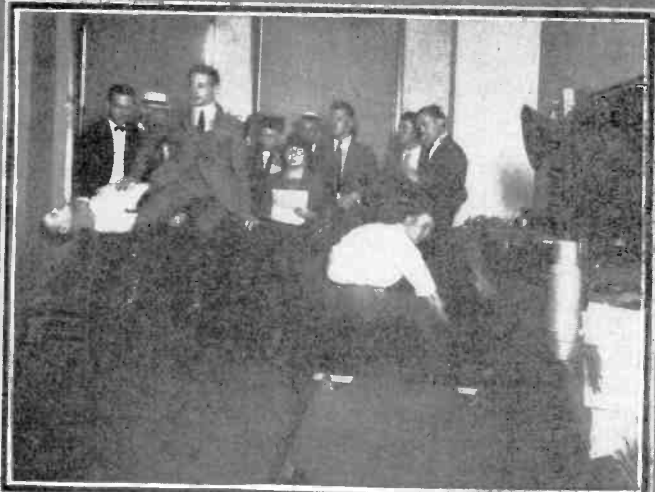
In every factory where optical goods are made, such as your eye-glasses, knowledge of velocity of light is of prime importance. Its velocity was determined by means of Astronomy. So you see that even your eye-glasses have their foundation upon Astronomical knowledge.

Outside of this, however, and the dollars and cents value of Astronomy, it may be said that there is nothing more enobling and more mind-elevating than the study of Astronomy. It purifies the mind and gives you an entirely different outlook upon the world. Cease being an ant looking across a rivulet of water!

EDITOR.







At the Top of This Page the Illustration Shows How "Radio-Hypnotism" Was Made Possible. Center, Photo of Mr. Joseph Dunninger, the Hypnotist. At the Left of His Photo, Hypnotizing the Subject Preparatory To the Needle Test. At the Right of Large Photo, Needle Test In Detail.

In the Two Photos Immediately Above This Space, the Receiving Set Used For Radio Hypnotism Is Shown, and In One of Them the Bridge Test In Execution May Be Seen. In the Other, the Hat Pin Is Passed Through the Hand of the Hypnotist's Subject. At the Left Is a Photo of WHN Station.

Hypnotism By Radio Now Possible

By EDWARD H. LONDON

LONG distance hypnotism via radio has been successfully demonstrated by SCIENCE AND INVENTION MAGAZINE and Radio Station WHN, located at Ridgewood, L. I. Never before in the history of radio has any such attempt been made, and that it was a success all those who were present will concede, except one newspaper reporter on the staff of a miniature publication, who would not be convinced that the subject was hypnotized, even if she herself had fallen into a trance alongside of him. Nevertheless more than a dozen newspaper reporters, two medical doctors, who would not permit their names to be published, and who arrived incognito at the SCIENCE AND INVENTION offices, at least as far as the newspaper reporters were concerned, and one eminent hypnotist, besides other spectators were present at the demonstration. All of these were enthusiastic at the success of the experiment.

GETTING READY FOR THE TEST

On Saturday, July 14th, at 10.00 o'clock in the morning, station WHN, which participated in this test, to the extent of opening up the transmitting station at full power, played several test numbers, so that we could tune in for them at the laboratories of SCIENCE AND INVENTION MAGAZINE, ten miles from the station. At the Ridgewood station, Mr. Joseph Dunninger, who needs no further introduction, as he is already well-known to the readers of this publication by his series of articles on "magic" now appearing, and by the fact that he is chairman of our investigative board on spiritualistic matters, was at the station.

Leslie B. Duncan, the subject, was stationed at the SCIENCE AND INVENTION offices in the presence of the newspaper reporters, physicians, and other spectators. After a short lecture, Mr. Dunninger, speaking into the transmitter at WHN, conveyed his voice to thousands of listening ears, but to one pair which they particularly impressed, inasmuch as his voice was directed to Duncan only.

THE HYPNOTIST SPEAKS

"Duncan," the command came, "I am speaking to you only. Look directly into the horn of the loud-speaker. You see my eyes looking into yours. You see me here before you. I forbid you to move. Your eyes are watering; they are tired. Your eyelids are drooping. Your body is becoming rigid—very rigid. You will remain standing, your arms at your side."

Then his voice addressing one of the attendants said: "Now, place the subject directly in front of you, his eyes open, and see whether or not his eyelids will twitch when the flame of a match is passed rapidly before them."

This effect was attempted, but it was not entirely successful, as there was a movement of the eyes. One of the reporters stepped forward and examining Duncan, stated that his muscles were not absolutely rigid. So word was sent to Mr. Dunninger at station WHN via a private telephone wire, connecting our office with that of station WHN that Duncan should be brought out of the trance and the effect tried again. The voice then came through the loud-speaker via radio again.

FIRST ATTEMPT NON-SUCCESSFUL

"To my listeners: I have just been informed that my first experiment was not an entire success. I will try it again in a few moments. Duncan, I am now speaking to you. I want you to relax."

Duncan did. He fell limply and almost to the floor, were it not for the fact that several sprang forward to hold him. In spite of several sharp slaps across the face he could not be aroused.

DUNCAN FAILS TO RALLY

Needless to say excitement reigned supreme for the moment. Rushing to the phone, Mr. Dunninger was informed by the attendant that Duncan had not come out of the trance, although he had relaxed as commanded. A discussion followed, during which it was discovered that the command to awake had not been given, but only the command of relaxation had passed through the air.

Again from WHN's station, came the words. "Duncan, I am your commander; I command you to awake when you receive a sharp slap on your cheek." Duncan did awake, but was not in a fit condition to undergo the second test for at least five minutes.

Bear in mind that Mr. Dunninger had not seen Duncan that morning, and there was absolutely no prearrangement of this experiment. It was an error that the first signal transmitted from station WHN was a command to relax rather than awake, and it was not until the complete resumé of commands was made, that we discovered the proper one had not been transmitted. At first we all thought that Duncan would stay in the trance and remain there until the hypnotist arrived at our offices and personally brought his subject back to consciousness.

A HUMAN BRIDGE

Five minutes later the commanding voice from WHN station again directed Duncan to stand before the loud-speaker. He was again placed in a state of catalepsy, his muscles rigid, and his shoulders on one chair and his feet on another, forming a veritable bridge upon which an individual could sit with ease. This effect is clearly shown in our photographs. Duncan promptly rallied to Mr. Dunninger's command, and after a short intermission was ready for the third test. This test without a doubt demonstrated the possibility of long distance hypnotism.

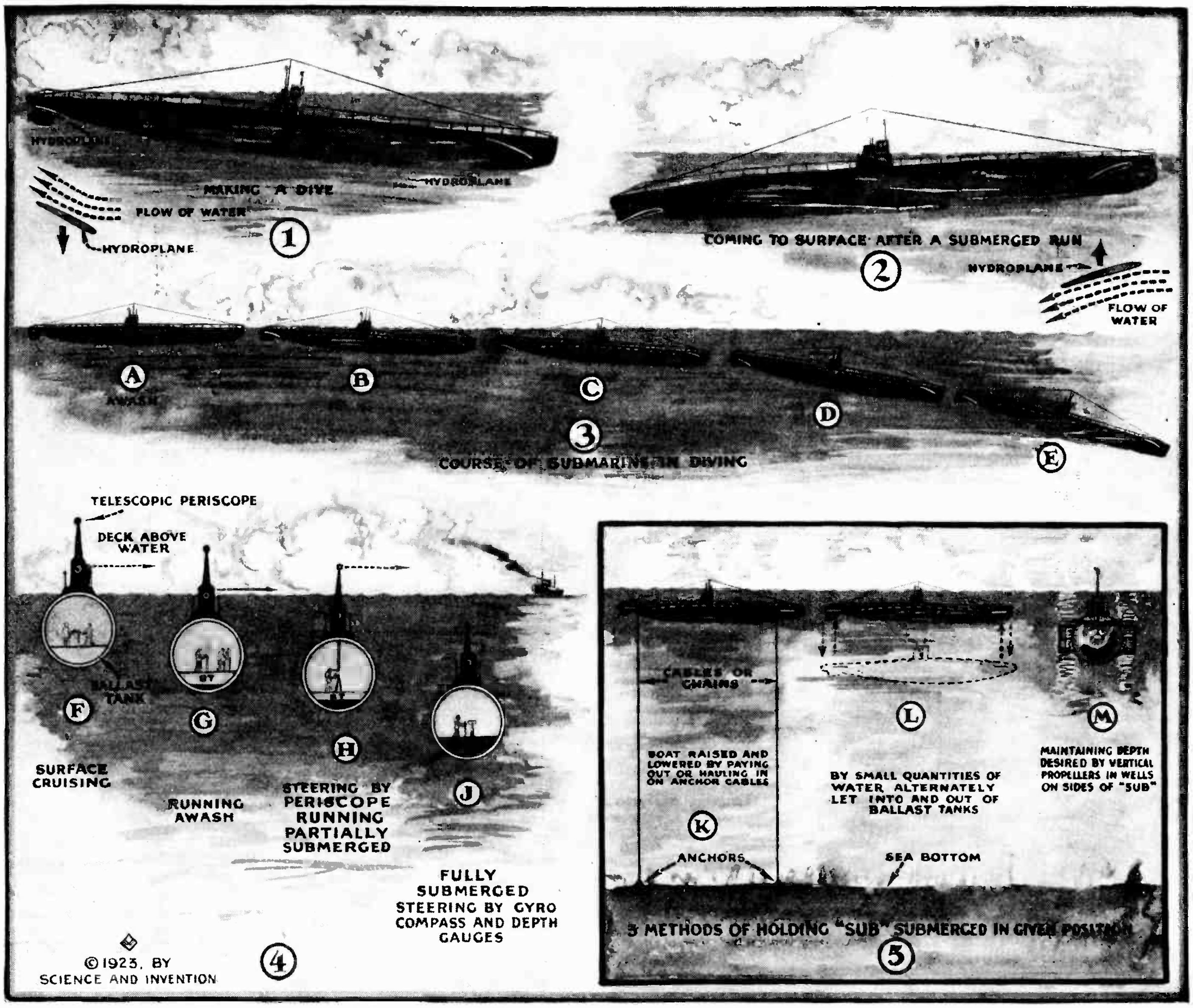
BLOODLESS AND PAINLESS NEEDLE TEST.

The subject was placed on a chair, his arm dangling over the side, and went into a state of catalepsy again at Mr. Dunninger's command, the muscles of his arm becoming perfectly rigid while those of the rest of his body were relaxed. A spot on his arm was sterilized, as was a lady's veil pin, and this was then plunged through the skin of the arm, which skin was lifted for the test. The pin punctured the skin very close to one of the superficial veins. In fact it even seemed to puncture the superficial vein and came out of the skin more than three-quarters of an inch away from its entrance. The subject did not flinch, and when the pin was withdrawn, there was no trace of blood seen coming out of the punctured marks. SCIENCE AND INVENTION did not like to conduct this last test, but the newspaper reporters were hardened. They wanted it proved that Duncan was absolutely in a hypnotic trance, and if this test, successful as it was, did not convince all of them, it convinced all but one. Undoubtedly readers of this article have already read the reports which were published in nearly every newspaper throughout the United States.

THE OBJECT OF THE TESTS

The tests proved conclusively that hypnotism may be successfully produced by radio, and that it now becomes possible for a good hypnotist, a medical doctor, to go to the nearest transmitting station and treat thousands of patients at one and the same time by means of this art. Each of the doctor's patients can have a small receiving set at home, and by listening to the voice of the radio, can be treated for insomnia with beneficial results, and by post-hypnotic suggestion for many other ailments. The treatment of chronic alcoholism and drug addicts has heretofore been successfully demonstrated by hypnotism. And why shouldn't hypnotism by radio be as successful as hypnotism by telephone? Radio has advanced to such a stage that the voice is as clear as over the telephone. With a multi-stage amplifier it is many times louder than the telephonic voice. Suppose that a very good hypnotist, internationally known, were to travel through the country giving hypnotic treatments and leaving his old patients behind in cities through which he has passed. He could then continue to administer further treatments from nearby broadcasting stations to his old patients and at the same time administer two or three personal treatments to each new subject. That this treatment may be developed more fully, and may be conducted throughout the United States at one and the same time by an efficient hypnotist, is the next step, the gap to which has already been bridged by SCIENCE AND INVENTION MAGAZINE, which has shown how this can be done. Further steps will soon be taken to develop more pronounced and lasting results following radio administered hypnotism.

This magazine wishes publicly to thank the operators and managers of Radiophone Station WHN for their kind and courteous cooperation in assisting in the first successful attempt at long-distance radio-hypnotism.



How Submarines Submerge, Travel At a Given Depth and Rise To the Surface: Fig. 1 Shows Submarine Diving At Slight Angle Usually About ½° Or Slightly More, By Depressing Horizontal Tail Rudders and Forward Hydroplanes. Fig. 2 Shows "Sub" Rising To the Surface. The Action of the Water On the Hydroplanes Is Explained In the Diagrams, With Resultant Upward and Downward Pressures. Fig. 3 Shows Successive Positions of Submarine Diving. Fig. 4 Shows Cross Section View of "Sub" and How Additional Water Is Taken Into Ballast Tanks To Reduce Buoyancy For Different Depths of Submerging. Submarines Are Made To Dive By Trimming To the "Awash" Condition, and Turning the Hydroplanes and Horizontal Tail Rudders Or Aft Hydroplanes To Proper Angles With Boat Underway. "Sub" May Navigate At Any Desired Depth By Suitable Adjustment of Water In Ballast Tanks and Hydroplanes. Fig. 5 Shows Three Ways of Maintaining "Sub" At Any Fixed Depth In Stationary Position—A, By Sinking Anchors and Taking Out Or Hauling In On Anchor Cables; B, By Alternately Blowing Out and Taking In Small Quantities of Water In Ballast Or Trim Tanks; and C, By Utilizing Vertical Propellers In Wells Extending From Sides of Hull, Sufficient Upward Or Downward Thrust Being Obtained As Required, By Varying the Speed and Direction of the Propellers.

How Submarines Dive and Rise

By IRWIN R. FAHRLAENDER

LATE OF THE U. S. NAVY SUBMARINE DIVISION

A SUBMARINE, in the most general acceptance of the term, is a vessel designed to operate at pleasure on the surface or submerged. All submarines involve the following principles:

Surface buoyancy, or displacement is destroyed by the admission of water ballast into specially constructed tanks called ballast tanks. The tanks are so located and of such size that the boat will naturally submerge on an even keel, and when these tanks are full the boat will have a very small percentage of positive buoyancy left, as about 75 per cent of her buoyancy is destroyed when fully flooding the main ballast tanks.

HOW A SUBMARINE DIVES

I will try to describe how a submarine makes a stationary dive.

We are running on the surface on the main engines when the following orders are given by the commissioned officer:

"Rig for diving."

Everything about the decks is secured, lines stowed, deck locker and gun secured, the colors taken down, the diving flag put up, and all navigating instruments are sent below.

All hands except the commanding officer and quartermaster, go below to their stations and see that everything is in readiness by actual test.

All hatches are closed, except the conning tower hatchway.

The next orders are:

"Stations for trimming down."

"Silence in the boat."

Everybody stands by for further orders.

The commissioned officer stops engines, and goes below, also the quartermasters.

Reports come in from all diving stations. *"Ready forward"; "ready aft,"* etc., are further orders.

"Flood M. B. T." (M. B. T. means main ballast tanks.)

This last named operation occupies less than a minute, when the said tanks are reported full; the air in the tanks has been expelled and replaced by water.

But still we are not ready to run. We still have about 25 per cent of buoyancy which must be cut down to enable us to handle the boat with ease as we flood our auxiliary and regulator tanks, which can be so regulated that the boat will be perfectly balanced at what is called neutral buoyancy. In other words, the boat now at neutral buoyancy is, as it were, suspended in a sort of indifferent buoyancy. In fact, if it were possible for a man to get outside of and

(*Continued on page* 491)

Important

Announcement!

THE October issue of SCIENCE AND INVENTION will witness an important and far-reaching innovation in the magazine field.

IN order to give our readers greater value for their money, the October issue, and subsequent issues of SCIENCE AND INVENTION, will contain almost *three times as much matter* as has been published in any previous issue.

THE editorial policy of SCIENCE AND INVENTION remains unchanged. The same material, only *three times as much of it in an entirely new form*, will be presented to our readers.

INCIDENTALLY, SCIENCE AND INVENTION will appear in a new make-up which will make its reading far more fascinating and interesting than it has ever been in the past.

THE EDITORS

What We Die Of

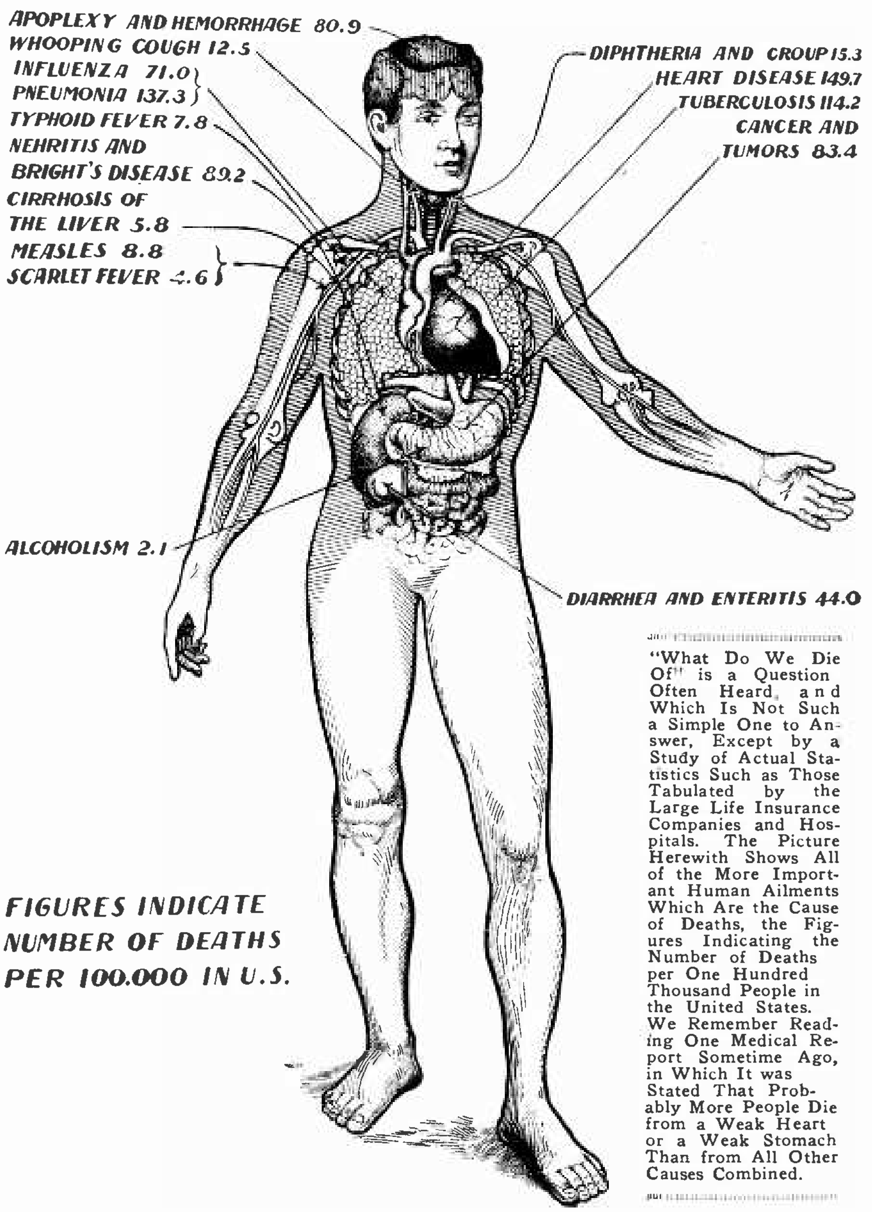
THE past year was the healthiest one in the history of the United States and Canada of any save one, the exception being 1921, and the margin between the two years is insignificantly small. The Metropolitan Life Insurance Company, who issue a statistical bulletin, in which they carefully record the mortality figures of their policy holders, have found that the death rate of these millions of insured persons was 8.8 per thousand lives in 1922, and 8.7 per thousand lives in 1921. These figures differ from those issued by the Government, but the general proportion is maintained. The reason that this year fell back slightly was because of the influenza outbreak in the early months of 1922, which made the record higher than that in 1921, although the latter half of the year showed the best health record ever made during the past fifteen or twenty years.

There was a sharp decline in deaths from tuberculosis, which eleven years ago was way in the lead as a cause of mortality. From this ranking position it has been displaced, so that now it is second in importance to organic heart diseases. The decline in deaths from tuberculosis was not so marked among white individuals as among colored persons. Typhoid fever was lower among insured wage-earners in 1922, and the communicable diseases of children, such as diphtheria, scarlet fever and whooping cough, show a lower death-rate during the year, although the measles death-rate rose slightly. The diphtheria death-rate was the lowest recorded in the past eleven years among insured wage-earners, and the same is true of the whooping cough. The scarlet fever rate was lower than in the year 1919, 1920 or 1921. Diarrheal conditions likewise took a marked slump, and there were fewer deaths this year than in former years from accidents not specified in the following sentence, drowning, burns, suicides and homicides. Deaths from drowning and burning have shown a downward trend ever since 1911. Influenza, pneumonia, organic diseases of the heart, diabetes, automobile accidents, and machinery accidents increased, the mortality statistics showing that 1922 was not as favorable as 1921 for these diseases and accidents. The upward movement of heart disease mortality occurred beyond the forty-fifth year, while in children and in adolescents the rating was normal. Cerebral hemorrhages were slightly higher this year than last year. The diabetes rate increased ten per cent during 1922, the highest recorded in twelve years, and alcoholism due to ordinary liquors, not to wood alcohol poisoning, rose as indicated by the statistical bulletin above referred to, from .9 per one hundred thousand to 2.1, or an increase of one hundred and thirty-three per cent. This is the highest death rate recorded for alcoholism since 1917, but it is still much lower than the rates in the years prior to 1918. These figures would indicate, therefore, that prohibition was of value in causing a marked decrease in the number of deaths due to alcoholism, because from 1917 to 1920 there was a downward trend in such mortality. Seventy-one individuals died of wood alcohol poisoning in 1921, but the record of victims of this drug have not been tabulated for 1922 up to the present time. Cirrhosis of the liver also declined. Machinery accidents recorded a sixty per cent increase.

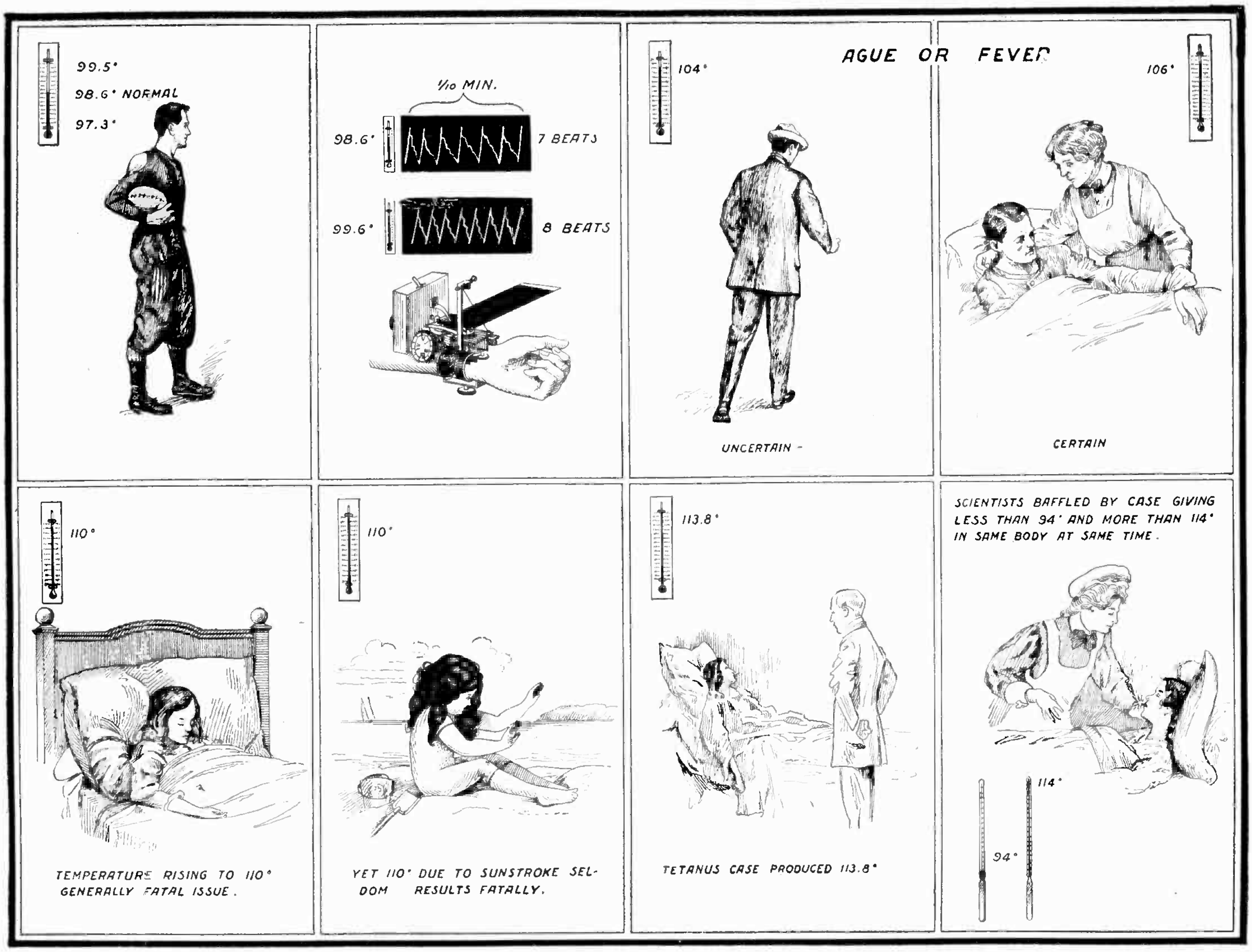
And now we have a challenge to the instinct of self-preservation of the American and Canadian populations. During 1922 the number of deaths caused by automobile accidents increased 10.7 per cent over the 1921 figure. The 1922 record caused the loss of lives at nearly six times the rate of 1911, and (you may write this on your cuff) forty-eight per cent of the deaths were of children under fifteen years of age.

In the general population for the registration area, exclusive of Hawaii, we find (the figures of which are given on our drawing) that the death-rate for 1920 was lower than for any year since the publication of annual reports in three of the items listed. Remember that now we are talking about the general population, not insured wage-earners alone which occupied our attention in the previous part of this article. These three are typhoid fever, diarrhea enteritis, and tuberculosis. On the other hand, the rate from diphtheria, croup and cancer is higher.

Very interesting information is given by the John Wiley publication, "Vital Statistics," by George Chandler Whipple, a standard text work on the science of demography. It would be well for anyone interested in living long to read this most excellent work. We find that the ideal family, according to the author in question, would consist of a father, a mother, three children and an occasional grandfather, grandmother, aunt or uncle. As the average number of persons per family in the United States is only 4.3, it is evident that our nation's families are much smaller than the ideal. It is surprising to note the number of persons about .14 per cent who really do not know their own age, and also that the population of the United States is increasing in spite of the rather difficult times. For instance, in 1918 there were seventy-three deaths for each one hundred births, but this was a high rate of mortality, effected by the influenza epidemic, which reigned at that time. In 1919 there were only fifty-eight deaths per one hundred births in the United States. In England the figures were ninety-two and seventy-three for the two years, respectively, whereas in Vienna and France the death-rate was appallingly high. In the non-invaded portions of France there were one hundred and ninety-eight deaths per one hundred births for the year 1918, which means that the population of France is decreasing rapidly, and in Vienna two hundred and twenty-nine and one hundred and sixty-two were the figures, respectively, for the two years mentioned per one hundred births.



"What Do We Die Of" is a Question Often Heard, and Which Is Not Such a Simple One to Answer, Except by a Study of Actual Statistics Such as Those Tabulated by the Large Life Insurance Companies and Hospitals. The Picture Herewith Shows All of the More Important Human Ailments Which Are the Cause of Deaths, the Figures Indicating the Number of Deaths per One Hundred Thousand People in the United States. We Remember Reading One Medical Report Sometime Ago, in Which It was Stated That Probably More People Die from a Weak Heart or a Weak Stomach Than from All Other Causes Combined.



The Body Has a Normal Temperature of 98.6° Which May Vary Between 97.3° and 99.5° F. With An Increase of Temperature of 1°, the Pulse Shows Ten Beats More Each Minute. As Indicated In the Second Illustration In the Top Row. A Person Can Walk Around In Seeming Health With a Temperature of 104, But When the Temperature Reaches 106, He Invariably Finds It Necessary To Go To Bed. In the Lower Row We Find That a Temperature of 110° Will Generally Result Fatally, Yet the Same Temperature Due To Sunstroke Seldom Causes Death. Very High Temperatures Have Been Recorded. A Tetanus Case Developed 113.8° Before the Patient Succumbed, Whereas a Patient Having Various Temperatures In Different Sections of the Body, Registering More Than 114° and Less Than 94°, At the Same Time, Is Still Alive.

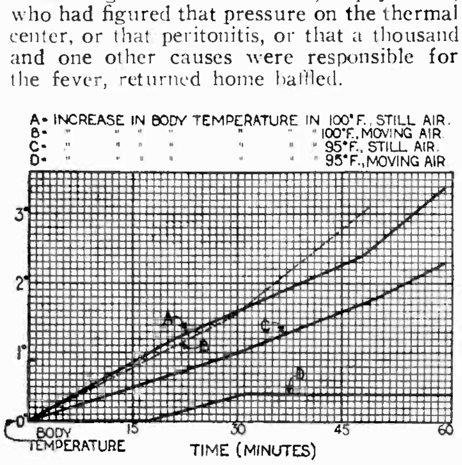
What Temperature Can We Stand?

By JOSEPH H. KRAUS

STAFF MEDICAL EXPERT

NO doubt you have all read of the sudden rise to fame of Miss Evelyn Lyons, the "Michigan Marvel," from Escanaba, Michigan. Miss Lyons was called "the girl with a temperature of 114°." On May 7th physicians were baffled with the abnormally high temperature which a thermometer registered, when held under the arm by the girl. The ordinary clinical thermometer will read to 110°, and is not graduated beyond that point, although it will require a temperature of approximately 114° to cause the mercury to reach the end of the capillary tube. When Miss Lyons placed the thermometer under her arm it lasted a few seconds, and was then cracked by the expanding mercury. The Weather Bureau had to come to the physician's assistance, furnishing longer range thermometers for the tests.

Medical men from all over the country were making guesses as to why her fever was so high. She had an unusually good appetite, was loath to remain in bed, and reports would have it that she even ran out and lay down in a snow bank in order to cool off. The proper cooling procedure would have been for Papa Lyons to have turned young Miss Evelyn over on his knee and administered a little additional heat, because Evelyn was found fooling the best physicians in the country by means of an ordinary hot water bottle. The miniature hot water bottle was concealed by the patient, being held under her arm, so physicians, who had figured that pressure on the thermal center, or that peritonitis, or that a thousand and one other causes were responsible for the fever, returned home baffled.



Each of the Curves On the Above Chart Indicates the Increase In Body Temperature When the Patient Is Placed In a Room Containing Still Air of a High Temperature, Or Moving Air of the Same Temperature. The Normal Temperature Is Taken As Zero On the Graph.

SIGNIFICANCE OF HIGH TEMPERATURE

One often desires to determine what the effects of high temperatures in the body or on the body would actually be. The normal temperature of the human body is 98.6° F., which varies a few tenths in either direction in different climates. Should there be a persistent elevation or depression in the temperatures above 99.5 or below 97.3, both in degrees F., one may be quite certain that a diseased condition is present. The average temperature of the human body is 1° higher in the tropics than in temperate regions. This increase of 1° generally increases the pulse beat, so that the pulse averages ten more beats per minute.

In cases of ague, the temperature of the body begins to rise and after the disease has been practically cured, this temperature is still found to be quite high. As long as it remains above normal, the patient is not entirely cured.

Supposing that a person of good habits and who only a few hours ago was perfectly healthy, develops a temperature of 104°F. It is an almost positive sign that he has developed an attack of ephemeral fever, or that ague is coming on. This temperature may further increase to 106°

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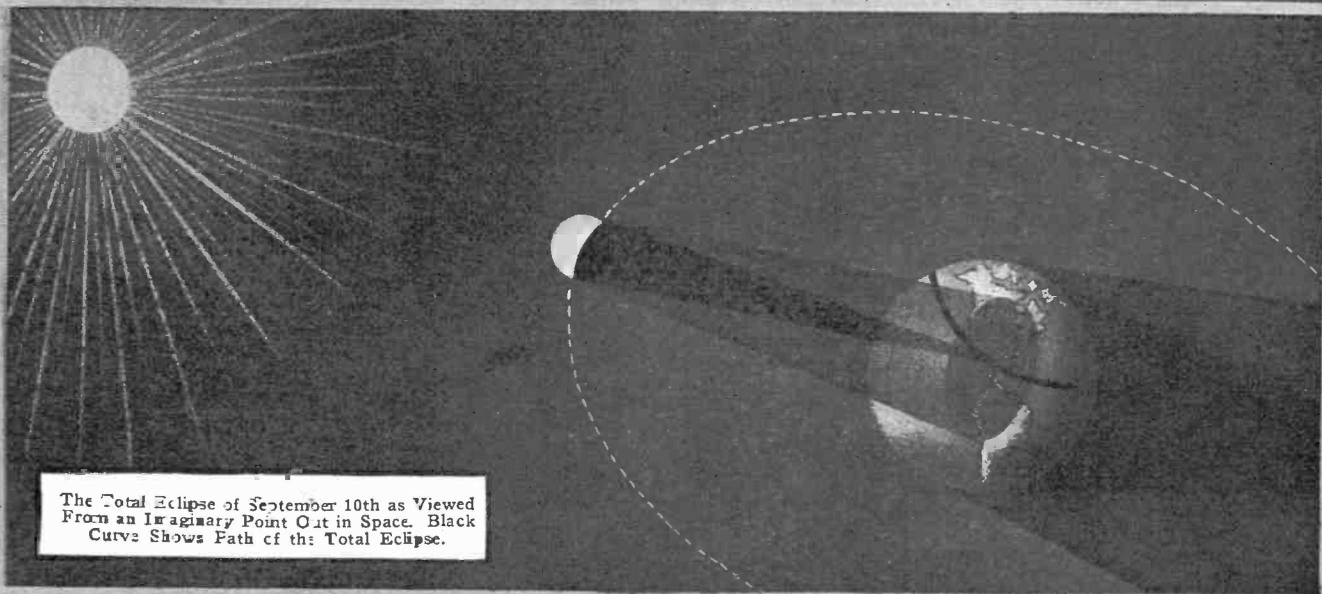
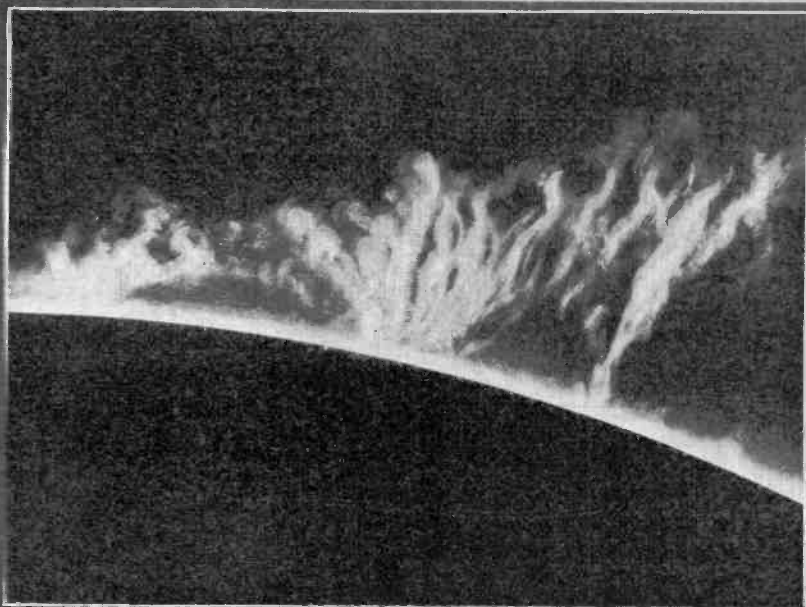
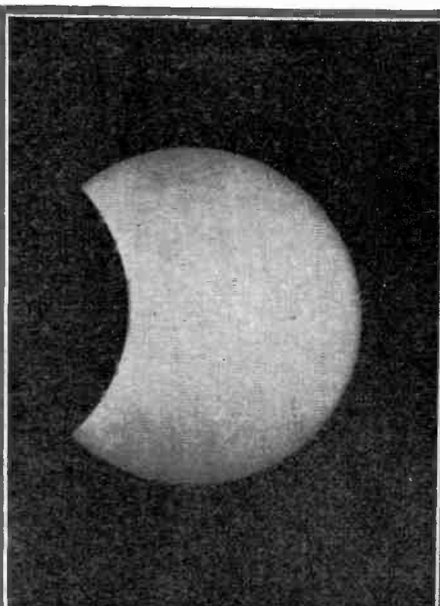


The Total Eclipse of September 10th as Viewed From an Imaginary Point Out in Space. Black Curve Shows Path of the Total Eclipse.

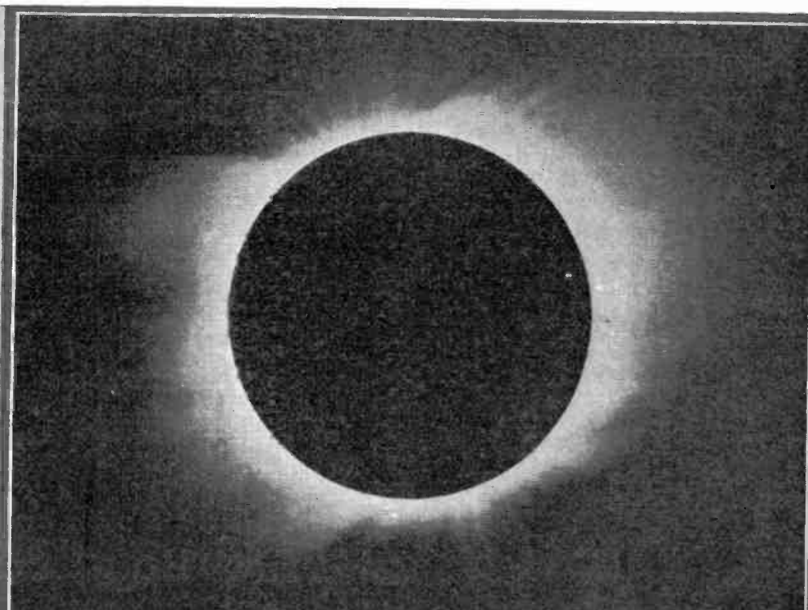


Solar Prominences of Incandescent Hydrogen 80,000 Miles High Rising From the Chromosphere. It Is Now Possible to Photograph These Great Eruptive Prominences Without the Aid of a Total Eclipse. The Dark Disk in This Photograph Is NOT the Moon, and This Was NOT Taken at Time of Total Eclipse, Though Such May Appear to be the Case.

As the Sun Will Look on September 10th in Certain Parts of This Country. This Is a Partial Eclipse. In Other Words, the Disk of the Moon Does Not Cover the Entire Sun.



Another View of the Partial Eclipse Which Is Even Less Than Last Illustration.



Total Eclipse of the Sun May 28th, 1900, Photographed by Yerkes. The White Streamers Are the Corona. Note Short Polar Streamers and Bottom.

Popular Astronomy

By ISABEL M. LEWIS, M.A.

OF THE U. S. NAVAL OBSERVATORY

The Total Solar Eclipse of Sept. 10th Visible in the United States and Mexico

UPON the tenth of September the United States will be visited by a total eclipse of the sun, the first to be visible in this country since the path of totality of the eclipse of June 8, 1918, crossed diagonally from Washington to Florida. To be sure, the path of totality of the coming eclipse will not much more than graze our shores in Southern California, but it will be at the most favorable part of its course when the sun is high in the heavens early in the afternoon and when the duration of the total phase is near its maximum value.

The Santa Barbara Islands, off the coast of Southern California, lie directly in the path of total eclipse, the island of San Clemente being on the central line. Point Concepcion and San Diego on the mainland are also well within the path of totality. The Mt. Wilson Observatory lies only thirty miles or so outside of the shadow path and ninety-eight and one-half per cent of the sun's diameter will be covered by the lunar disk at that point at the time of greatest obscuration. Plans are being made to observe the eclipse on Mt. Wilson as well as within the path of total eclipse, and it is expected that some interesting results may be obtained with the aid of the powerful astronomical equipment of this observatory which is second to none in the world. It is hoped that the fifty-foot interferometer may be completed in time for use at this eclipse.

TIME DURATION OF ECLIPSE

At San Clemente Island the total phase of the eclipse begins at about 12:56 p. m., Pacific Standard Time, and the duration of the total phase will be 3m 36s, which is within one second of the longest duration at any point on the central line. This compares very favorably with the scant two minutes, at the most, afforded observers of the 1918 eclipse. The Lick Observatory expedition to Wallal, Australia, which so successfully observed the eclipse of last September and obtained such striking confirmation of the Einstein prediction, was favored with a duration of a little over five minutes. The duration for the coming eclipse is about that of the average total eclipse. The greatest possible duration of a total eclipse is 7m. 58s. and this occurs only under very exceptional circumstances which are rarely fulfilled.

MEXICO IDEAL SPOT TO VIEW ECLIPSE

There are many excellent points of vantage for the observation of this eclipse not only among the Santa Barbara Islands and in the vicinity of San Diego, but also in Mexico. Here the shadow path passes over Lower California and across the mainland from the Gulf of California to Yucatan. The Mexican National Government, the Council of Mexico City, the Governor of San Luis Potosi, the Director of the National Observatory at Tacubaya, Prof. Gallo and the Mexican National Railways have offered many courtesies and offers of assistance to astronomers of other countries who are planning to observe the eclipse in Mexico. All necessities of expeditions going to Berrendo, a point on the central line midway between Cuencame and Tampico, will be provided by the Governor of San Luis Obispo and all facilities will be granted to the visitors. The National Railways are also offering a discount of fifty per cent to Mexico City and other points where the eclipse will be observed.

The Lick Observatory Expedition will locate in the neighborhood of Ensenada, Lower California, with an extensive equipment, though no further attempts will be made to obtain plates to test the Einstein effect, owing to the nearly perfect agreement between observation and theory that was obtained by this expedition last September at Wallal, Australia.

Certain other expeditions will attempt to obtain photographs of the star-field surrounding the sun, however, for the purpose of detecting this Einstein effect, due to the bending of the rays of light from the stars upon passing near the sun which causes the star images to appear displaced on the photographic plates from the positions they would normally occupy, not only away from the sun, but by an amount varying with distance from it.

An expedition from Germany will observe the eclipse in Mexico at the invitation of the Mexican government and the test of the Einstein effect will be part of the program of observation.

At Cuencame, Mexico, there will be an expedition from the Sproul Observatory of Swathmore College, which is planning to obtain plates to test the Einstein effect, as well as to photograph the solar corona with lenses of 65 feet, 104 inches and 38 inches, respectively, to photograph the flash spectrum, which appears just preceding and following totality, and to test the corona for rotation with the interferometer.

The Mexican Government will send out two expeditions, one to occupy a station near Cuencame and the other a station at Berrendo. Photographs and drawings of the corona will be made and moving pictures of the eclipse will also be taken.

An expedition from the Steward Observatory of the University of Arizona under the leadership of Director A. E. Douglass will locate on the central line south of Hermosillo in Mexico. Amateur observers are also showing great interest in this eclipse and a group of Arizona amateurs are planning a pilgrimage into the wilds of the Sonora desert to the central line by automobile, a distance of 160 miles. Other amateurs interested in observing the eclipse are invited to join the expedition which will start from Douglas on the border. The equipment will consist of whatever astronomical instruments may be obtainable. The artists of the expedition may try their skill in making drawings of the coronal streamers and many of the details of form and structure which may be caught even better by the human eye than by the photographic plate. All members of the expedition, if the weather permits, will be afforded a view of one of the grandest spectacles that nature has to offer.

On Catalina Island there will be several expeditions. The Yerkes Observatory expedition will be stationed here with an extensive equipment, and also an expedition from the Washburn Observatory of the University of Wisconsin which will measure the brightness of the corona by means of the photo-electric cell. The Goodsell Observa-

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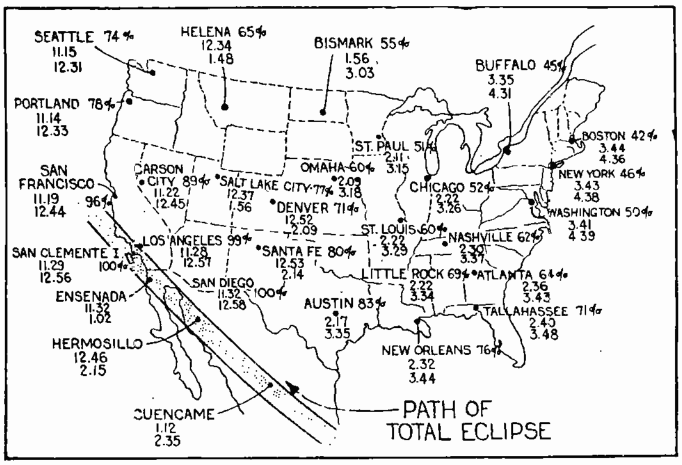
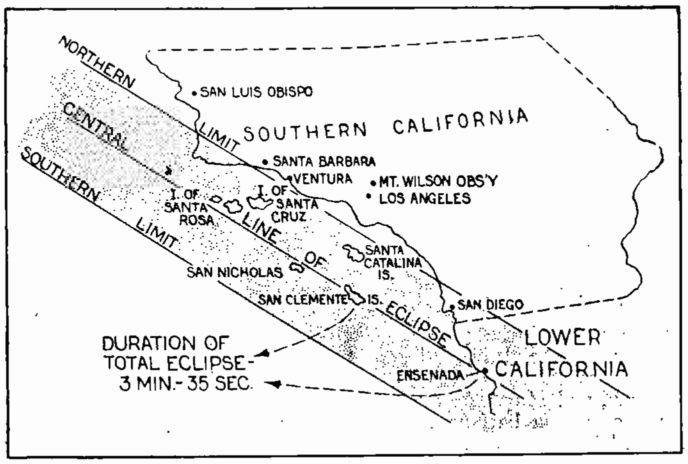
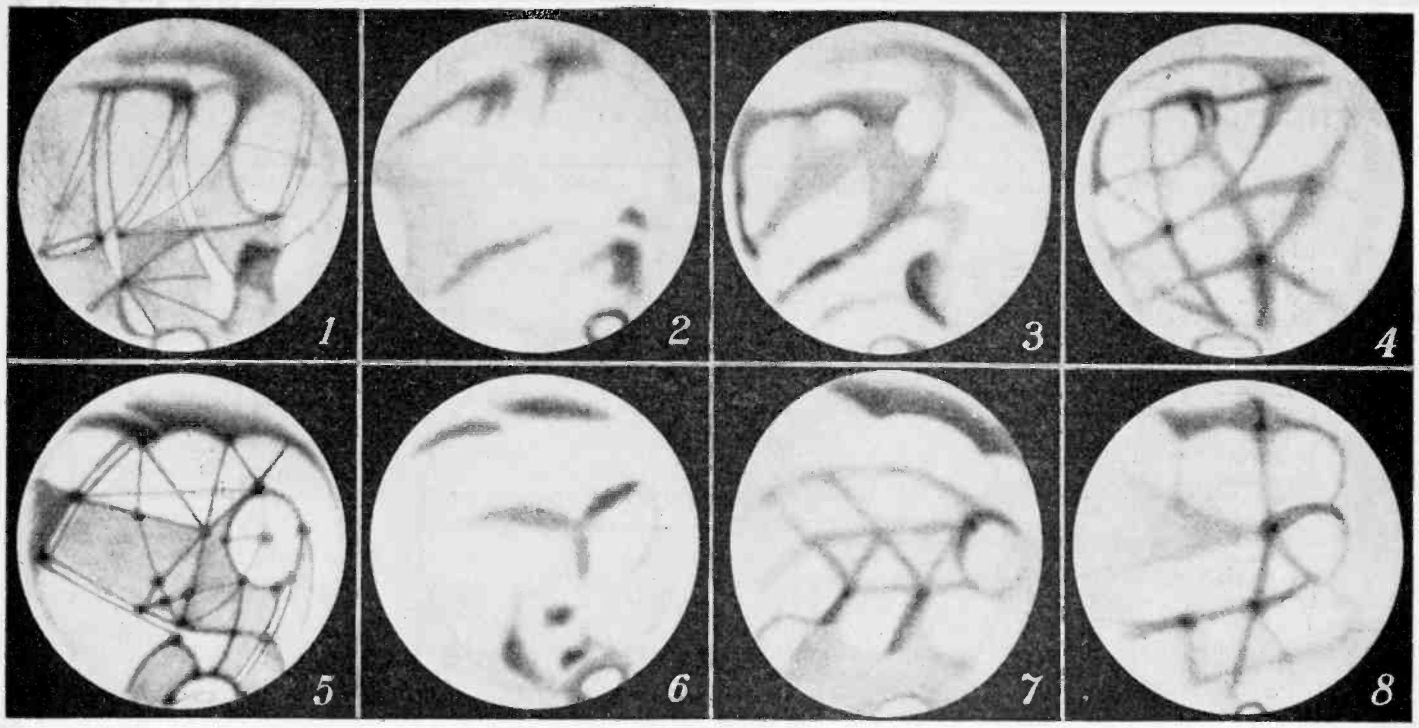


Map Showing Path of Total Eclipse in United States and Mexico and Local Standard Times of Beginning of Eclipse and Greatest Eclipse With Per Cent of Obscuration for Various Cities in the United States.



Map Showing Path of Total Eclipse Over Santa Barbara Islands, and Southern and Lower California. Most Favorable Points Will Probably Be Santa Catalina Island and Vicinity of Ensenada.



The Planet Mars As It Appears Through the Telescope When Viewed By the Observer. These Are Not Photographs of the Planet Mars Showing the Canals, For the Reason That It Is Almost Impossible To Secure Good Photographs of the Very Fine Line Net-Work of the Planet's Surface. The Reason Is Due To the Earth's Atmosphere, Which Tends To Blur the Fine Spider-Web Structure That Covers the Face of Mars. We Show Drawings Made By Different Observers. Comparisons Were Made of a Number and In Many Cases the Drawings Coincided Perfectly, Although Made By Observers Thousands of Miles Apart. It Is Professor Pickering's Belief That These Canals Are Not Artificial, But Can Be Explained By Natural Means.

The Planet Mars

By Prof. WILLIAM H. PICKERING

HARVARD COLLEGE OBSERVATORY, MANDEVILLE, JAMAICA, B. W. I.

THE year of Mars is about twice as long as that of our Earth, consequently in our path around the Sun we are continually overtaking it in a period of a little more than two years. At such times, since the path of the planet is quite eccentric, we occasionally pass comparatively near to it, that is to say within 35,000,000 miles, which seems near in astronomy. This will happen on August 22d of next year, when we shall be nearer to Mars than has been the case for over 120 years. Nor shall we be as near again during the present century. The planet will then appear very large and red in the sky, so that anyone can easily recognize it. But it is not merely that it will be nearer to us than usual next year, but also that it will be near us for a very long time, which is much more important. We therefore hope to secure many interesting observations of it. The season on Mars will be the middle of November for its northern hemisphere, or late spring for its southern. The south pole of the planet will therefore be turned towards the Earth, and we shall be able to study the whole of the southern hemisphere to great advantage.

The drawings illustrating this article were made in 1920, when the northern hemisphere was turned towards us, and they show that hemisphere very clearly. Like all planetary drawings north is placed at the bottom of the picture, and the northern snow cap is distinctly shown in each of them, thus locating the pole of the planet. The Martian month was late July and early August, though most of the drawings were made in our April and May. At that time the Earth was once and a half as far from Mars as we shall be next year.

HOW MAPS OF MARS WERE MADE

These drawings were all made by expert observers belonging to the international society devoted to the study of Mars. This society includes in its membership all of the best known planetary astronomers throughout the world. Under each original drawing is the name of the observer, and the longitude of the planet's central meridian at the time that the drawing was made. Referring to the drawings individually, it may be said that Dr. Maggini believes that he should draw everything that he sees, or thinks that he sees. Some of this detail is so faint that in order to show it at all he has to greatly exaggerate its density, so that, as he himself admits, his drawings for this reason really do not look like the planet, but are more nearly analogous to a map. The other observers insist on drawing only those things of which they are absolutely sure, feeling that it is better to omit some real detail than to draw something else that is not there.

WILLIAM HENRY PICKERING is one of the best known astronomers in the world today. He is an expert on the subject of Mars, and we are sure that our readers will enjoy this specially written article by Professor Pickering. He is a Fellow of the American Academy, a member of numerous astronomical societies, and he holds the order of the Chevalier Saint James of Portugal. We are fortunate indeed in having procured this timely and exceptional article for SCIENCE AND INVENTION, by so prominent and brilliant an investigator of stellar mysteries.—EDITOR.

Since the drawings were not all made on the same night, or even during the same week, and since the surface of Mars is continually changing, we should not expect them to be all exactly alike. At the same time they should bear a very close resemblance to one another.

These facts will explain why there are two distinct schools of observers of Mars—the more radical, and the more conservative. Which is right only the future will decide. Dr. Maggini's drawings show innumerable lakes, and several of the famous double canals of Mars. That some of these canals exist as canals there is no manner of doubt. The only question is as to whether their sides are darker than their middles. Most of the observers apparently think not. It is hoped that this matter may be definitely decided next year.

SURFACE CONDITIONS ON MARS

We will now discuss some of the better ascertained facts relating to the surface conditions on the planet. The most important one, on which most of the others depend, is that the force of gravity there is only two-fifths as great as it is on the Earth. A man weighing 150 pounds here would weigh but 60 pounds if transported to Mars. Consequently the density of its atmosphere is much less than ours, probably about one-quarter as great. Also there is very much less water on the planet, hardly as much as would be contained in one of our great lakes. There are no permanent water areas as with us, and water is only seen in the liquid form temporarily, at the edges of the melting polar caps. Those large dark areas on the planet which temporarily turn a bright blue, indicate, it would seem, like the green maria, merely a process of vegetation.

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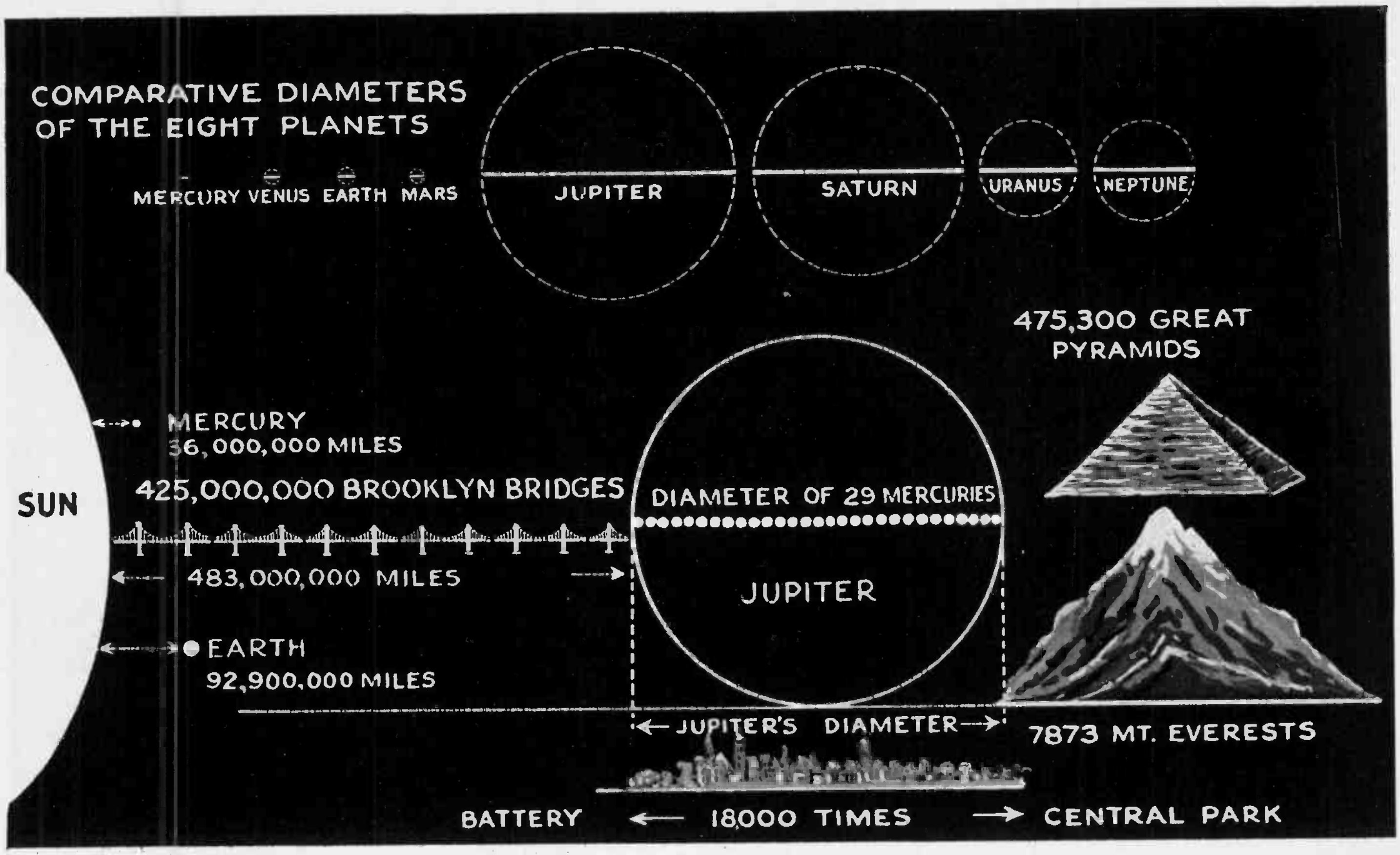


The Chart Above Shows In a Striking Manner the Comparative Sizes of the Eight Planets Constituting the Solar System. Mercury Is the Smallest of the Planets, While Jupiter Is the Largest, Having a Diameter Equivalent to Twenty-nine Mercuries. Jupiter's Diameter Is 18,000 Times the Distance From the Battery to Central Park, N. Y. C., and It Will Need Over 400 Million Brooklyn Bridges to Bridge the Gap Between Jupiter and the Sun.

The Largest and the Smallest Planets

By CHARLES NEVERS HOLMES

EIGHT planets constitute the planetary membership of our Solar System. Of course, these planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. There may exist other planets, besides these eight, but astronomers have not as yet discovered a ninth planet. In order of respective size, these eight planets are Jupiter, Saturn, Neptune, Uranus, Earth, Venus, Mars and Mercury.

Accordingly, the largest planet of our Solar System is Jupiter, the smallest is Mercury. Both Jupiter and Mercury vary in their distances from the Sun and from our Earth. Jupiter revolves at a mean distance of 483,000,000 miles from the Sun; it may approach as near as 370,000,000 miles to our World or recede as far as 600,000,000 miles from us. Its mean distance from the Sun is, therefore, not quite 1/6th that of Neptune, the farthest planet from our Sun. Mercury is not only the smallest of the eight planets but it is also the nearest to the Sun. It revolves at a mean distance of 36,000,000 miles from the Sun, and its distance to our Earth varies from 50,000,000 to 136,000,000 miles. At its nearest distance to us, Mercury approximates 1/7th of Jupiter's nearest distance to us.

The "year" of the planet Jupiter is almost twelve times as long as our Earth's. The "year" of Mercury only about 1/4th that of the World's. As we well know, our Earth's year is approximately 365¼ days of length. The reason for Jupiter's longer year and Mercury's shorter year is owing to Jupiter's longer orbit and Mercury's shorter orbit around the Sun and to their relative speeds. Around our Sun, the latter planet speeds with a velocity of 23 to 35 miles per second, the former planet with a velocity of only 8 miles per second.

The density or solidity of Jupiter is estimated to be even a little less than that of our Sun. There have been a number of estimates respecting the density of Mercury. Whereas Jupiter's solidity approximates only about one-quarter that of our Earth, Mercury's density has been estimated from 85/100ths of the terrestrial density to a density comparable with our Earth's. Now, our Moon is almost 2/3rds as solid as our Earth. In other words, our Earth's density is about 5½ times that of water, Jupiter's density a little greater than that of water, whilst Mercury's has been estimated, upwards, from 4 7/10ths times the density of water.

All the eight planets vary respecting the so-called weight of bodies at their surfaces. The weight of a body on the planet Jupiter is about 2 65/100ths times the weight of such a body, were it weighed upon our Earth's surface. That is, one of us who weighs 150 pounds here, would, were he transported to Jupiter's surface, weigh almost 400 pounds. Of course, Mercury is smaller than either Jupiter or our World, so that we should expect a 150-pound body to weigh less there than what it would on either of the other planets. A good estimate would perhaps be about 60 pounds. Compared with these respective weights, a 150-pound body would weigh about 25 pounds on the Moon and more than 2 tons on our Sun. These calculations leave centrifugal force out of consideration.

There are many other interesting facts about the largest planet and the smallest planet of our Solar System. We know that it takes our own Planet about 24 hours to rotate once around its axis. Now, Mercury takes about 88 days to complete one of its axial rotations, and Jupiter only about 10 hours. That is to say, the planet Jupiter rotates more swiftly around its axis than any of the 7 other planets. Respecting moons or satellites, Mercury possesses no known moon, whereas Jupiter has 9 known moons revolving around it. One of Jupiter's moons, Ganymede, is larger than the planet Mercury, and another one, Callisto, is almost as big as Mercury.

And, now, how large is the largest planet in our Solar System and how small is the smallest planet?

The diameter of Jupiter is more than 86,500 miles, our Earth's diameter being about 7,918 miles. Accordingly, Jupiter's circumference is more than 10 times that of the earth, and this giant planet's volume is over 1,309 times greater than our own planet's volume. With respect to some of the other planets, Jupiter is about 1 7/10ths times as large as Saturn and nearly 9,000 times as large as Mars, and approximates the volume of 24,000 Mercuries, combined in one planet. It is 64,000 times as large as our moon.

As for the planet Mercury, its diameter is about 3,000 miles, or nearly 39/100ths the diameter of our World. Accordingly, this pigmy planet's volume is only about 1/18th of our Earth's volume. The planet Saturn is some 14,000 times as large as Mercury, and the planet Mars almost 3 times as big. Mercury is larger than our Moon, but only 2 3/4ths times as large.

Around the Universe

By RAY CUMMINGS

THIRD INSTALLMENT

The Sky Travelers Were Greatly Impressed Upon Their First View of the Landscape and Buildings on Jupiter. The Buildings Were Erected in Great Terraces.

SYNOPSIS OF TWO PRECEDING INSTALLMENTS OF "AROUND THE UNIVERSE"

WHILE watching a game of cards "Tubby" suddenly finds himself out in the open under the stars. He also finds that he has been endowed with a power of wishing and having his wishes come true. He wishes that he could know all about the stars and astronomy and there appears before him a man who introduces himself as Professor Isaac Swift DeFoe Wells-Verne. The Professor tells "Tubby" that he will teach him all about astronomy. Tubby then wishes that he could travel everywhere in the universe and before them appears a space flyer which Sir Isaac says is his invention. They start for Venus.

Landing on Venus, they meet a young lady whose name is Ameena. She tells them that the earth is in danger. Her people have found out that the Martians are about to descend upon the Earth and conquer it. Emissaries from both Mars and the Twilight People of Mercury, as the latter are going to assist the Martians, have been to Venus and tried unsuccessfully to enlist the aid of the Venusians. She says that the armies of Mars and Mercury have already conquered the Moon and placed outposts there.

The Professor decides that they must go for help to the Light Country located on Mercury, as its inhabitants are not going to enter into the war. At 7:29 p. m., Professor, "Tubby" and Ameena land upon the surface of Mercury.

CHAPTER V

IN WHICH THE MERCURIANS PROVE THEMSELVES UTTERLY SELFISH, AND THE DISAPPOINTED VOYAGERS, PURSUED BY THE ENEMY, HASTEN TO JUPITER

HOW selfish is human nature the Universe over! After a voyage of some thirty million miles, the travelers might quite as well have remained on Venus! The Mercurians of the Light Country were sorry—indeed, they greatly deplored the action of their neighbors of the Twilight Country in joining with the war lords of Mars against the unoffending Earth—but they would do nothing about it! How simple all human problems become, when viewed in that detached spirit! How human nature does repeat itself, wherever in the Universe it may be found!

The audience with the ruler of the Light Country took place at 9:40 p. m., Earth's Eastern Time—shortly after the First Meal, as time chanced to be on Mercury.

Tubby, Sir Isaac and Ameena gravely faced the white-haired King and his aged dignitaries who were seated around a huge table in the Audience Room. The place was crowded; its gallery above, open to the public, was thronged with those curious to see these strange visitors from another world.

Sir Isaac, who, fortunately, was fairly fluent in the Mercurian tongue, explained their mission. He was earnest and eloquent. And when he had finished, having done his very best, the King, after a whispered conference with his councillors, made his speech of condolence!

Sir Isaac was aghast. He translated the King's words briefly to Tubby and Ameena.

"How dare they?" the girl cried. "It is inhuman. Tell him *I* say——"

Sir Isaac interrupted her, in a whisper, for the Audience Room was intensely quiet.

"*Your* position is not so impregnable, Ameena. Your own people refused to mix up in this inter-planetary war. How can you expect——"

"My people have no weapons of war," she defended passionately. They know nothing of fighting. Never has a voice been raised in anger in my world! What could they do to help, if they would?"

"You let her alone," Tubby whispered vehemently to Sir Isaac. "She's got the right idea. You tell this King *he* can help. Ain't he got that Light-ray? Make him lend it to us."

Sir Isaac then requested the use of the Light-ray—a sufficient amount of its apparatus which they could set up on Earth for defense.

At this a stir ran over the assemblage. The King's guards, squat little men in leather jackets and wide, knee-length leather trousers, shouted for order. Several young girls flapped their long red-feathered wings—only the women had wings, it seemed—and one fluttered across the room near the ceiling, until commanded by the guards to cease.

The King looked exceedingly grave at Sir Isaac's request; his whispered conference with his advisors lasted several minutes. At last he shook his head.

Sir Isaac translated his answer. "He says he is sorry. They could not trust their Light-ray to another world. He claims the Earthmen would then learn its secret and some day might use it against Mercury."

"He's a fool!" shouted Tubby angrily. "Ain't they got it on Mars already? An' maybe on Jupiter?"

TUBBY SASSES THE MECURIAN KING

He turned toward the King. "Say listen here you——"

Thirty feet separated Tubby from the King at that moment, but he encompassed it in one bound, for on so small a planet as Mercury even Tubby weighed hardly sixty pounds! He landed beside the King's chair.

"Say, listen here you——"

As Tubby's fat little body went hurling through the air pandemonium broke out in the room. Girls were fluttering about; the guards were pushing and shoving the crowd. One or two of the older women fainted. A little boy broke into terrified screaming.

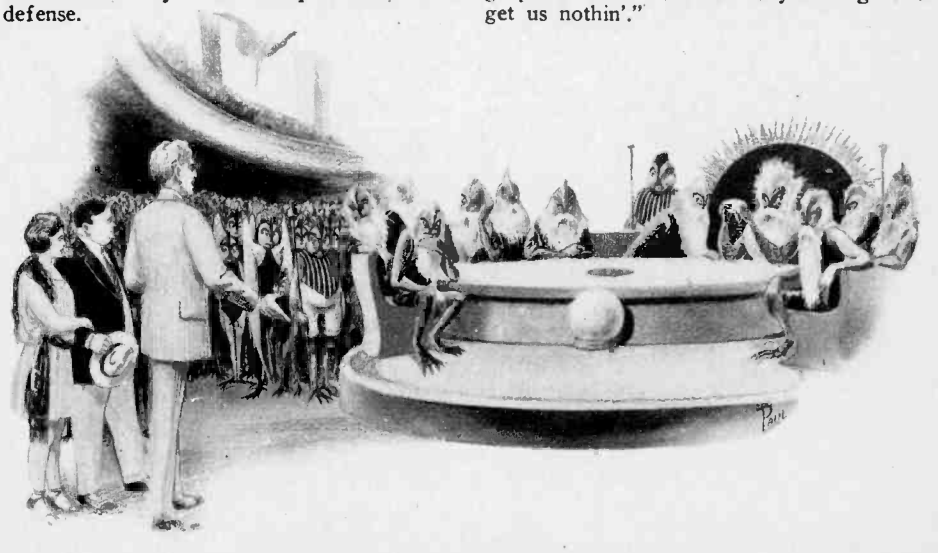
The King, finding he was not hurt, ignored Tubby's fist in his face, and with rare presence of mind rose to his feet, shouting reassuringly to the assemblage. Three of the nearest guards, their faces dark with anger, were making for Tubby belligerently; one of the aged counsellors put a restraining hand on his shoulder, but he shook it off.

Sir Isaac bawled:

"Come back here, you fool! They'll kill us all!"

It was Ameena's pleading voice, rising above the tumult, that brought Tubby to his senses. He stopped abruptly his abuse of the King, and with another prodigious bound leaped over the heads of the intervening people, and landed back beside his friends.

"Come on, let's get out of here," he gasped. "This here Mercury ain't goin' to get us nothin'."



The Three Interstellar Travelers Lay Their Plans Before a Court Session on Mercury—But to no Avail.

Sir Isaac, with true diplomatic suavity, waited until order was restored. He then paid his respects to the King, apologizing for Tubby's conduct, and stating with curt dignity that the Earth would solve its own problems and look after its own safety in its own way. After which, escorted by the King's guards to protect them from the incensed populace, the three visitors coldly departed.

As they left the room, a young girl—with huge wings and a sneering, unpleasant face, so different from the beauty of the other girls in the room as to mark her of another nation—climbed from the balcony into one of its outer windows. Poised there a moment, she launched herself into the air, spread her wings and flew away.

Sir Isaac, Tubby and Ameena were on the palace steps when this girl flew past, just over their heads. She shouted something venomously at Sir Isaac, and rising higher, flew rapidly toward the Narrow Sea and the Twilight Country.

Sir Isaac did not mention this incident then to Tubby or Ameena, who had not noticed the girl. Indeed, he forgot it in a moment, though afterward it was brought most vividly and unpleasantly to his memory.

FLYING THROUGH SPACE ONCE MORE

It was 11:45 p. m., Earth time, when the vehicle was again launched into space. When they had passed over the Dark Country and had left the atmosphere of Mercury—headed this time away from the Sun, back toward Venus and the Earth—the three interplanetary adventurers sat down quietly in the instrument room to determine what should now be done, in the face of this unexpected disappointment.

"An' here we went an' wasted all day," Tubby moaned. "We could have been almost anywhere while we was foolin' around here with them selfish, pin-headed——" He trailed off into abuse of the Mercurians.

Sir Isaac, more practical, summed up the situation as it now stood.

"We have, of course, no means of knowing whether the inhabitants of Jupiter are against us or not," he said. "But at all events, at the next opposition of Mars with the Earth we may expect their attack."

"Less'n two months from now," Tubby put in gloomily.

"In fifty-six days and eighteen hours," Sir Isaac corrected. "I assume their method will be to mass their army first upon the Moon. From that point of vantage, always close to the Earth, they can launch their successive attacks at will."

"That is what they will do," Ameena cried. "From the Moon, of course."

Tubby frowned. "What will they do to the Earth? You say they're goin' to kill us, but you ain't never said how."

Then Sir Isaac, his voice trembling in spite of himself, explained the horribly destructive power of the Mercurian Light-ray—that beam of red-green light-fire, which from giant projectors ignited everything within its path over a distance of fifteen miles! And the tremendous war-machines of the Martians — giant mechanical bodies housing the Martian directing brain in their tops —mechanisms with metal legs like steel girders fifty feet long running rampant over the Earth!

Together the Two Men Rushed Up Into the Little Observatory of the Space Flyer. Another Vehicle Twice as Large as Their Own and Somewhat Different in Shape, Hovered Almost Directly Above Them, Showing as a Dark Spot in the Firmament and Edged With Silver From the Sun's Rays Behind It.

"That's enough!" interposed Tubby hastily, mopping his face. "Don't tell us nothin' more like that. My idea is, we better not let 'em land on the Earth."

"Quite right," agreed Sir Isaac. "But how to prevent them? That's just the question."

It was the question indeed, and for another hour they wrestled with it.

"Let's eat," Tubby suddenly announced. "We can do that if we can't do nothin' else."

Tubby now found himself, after this episode on Mercury, somewhat more in the nature of leader of their enterprise than he had been before.

"We're done with Mercury," he said, when over the midnight supper the argument was resumed.

Sir Isaac nodded. "We are, most certainly."

"An' Venus ain't no use to us."

"No," Ameena put in. "My world is powerless."

Tubby went on with merciless logic:

"If we go home an' wait, we're licked sure."

"Yes," agreed Sir Isaac, "that will mean absolute annihilation, even though the world's armies and navies were massed to our defense."

"An' we *can't* land on the Moon," Tubby persisted. "They'd murder us in thirty seconds—on our own Moon too." The pathos of this struck Tubby with sudden force. "Ain't that actually criminal? Can't land on our own Moon!"

"What *are* we going to do?" Ameena asked hopelessly. "Oh, dear, we cannot seem to land anywhere."

"How about Jupiter?" Tubby demanded. "That's a big place, ain't it?"

"The largest planet of the solar system," said Sir Isaac. "But whether they are friends or enemies——"

"Well let's go see an' find out!"

The logic as well as the daring of this simple suggestion was immediately apparent.

"If them Jupiter people ain't enemies they can help us easy," Tubby added. "Let's take a chance anyway."

There seemed nothing else to do. The Earth was powerless to defend herself. Help must be obtained—from whatever source—at all costs.

And so it was decided.

THE COURSE SET FOR JUPITER

Back in the instrument room Sir Isaac computed their course to Jupiter. A little later, for it was then nearly three o'clock in the morning, Ameena retired to the upper floor.

The vehicle had now reached a point in space almost midway between Mercury and Venus. Tubby, suddenly remembering the asteroid with which they had so nearly collided that afternoon, peered anxiously down through the lower window, to the tiny blue-white disc among the stars that was Venus.

Sir Isaac, hearing Tubby's muttered exclamation concerning the asteroid, laughed reassuringly.

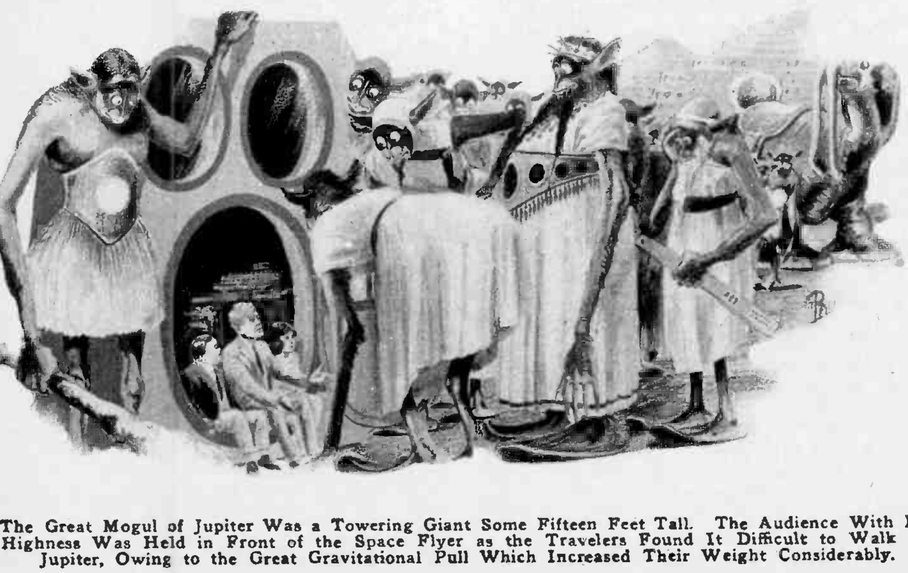
"It has passed on in its orbit," he said. "Rushing around the Sun in a most eccentric ellipse, it is now many million miles from here."

Having been the one to suggest their future course of action, Tubby was feeling his growing responsibility. He felt simultaneously his need for more specific astronomical information than he now possessed.

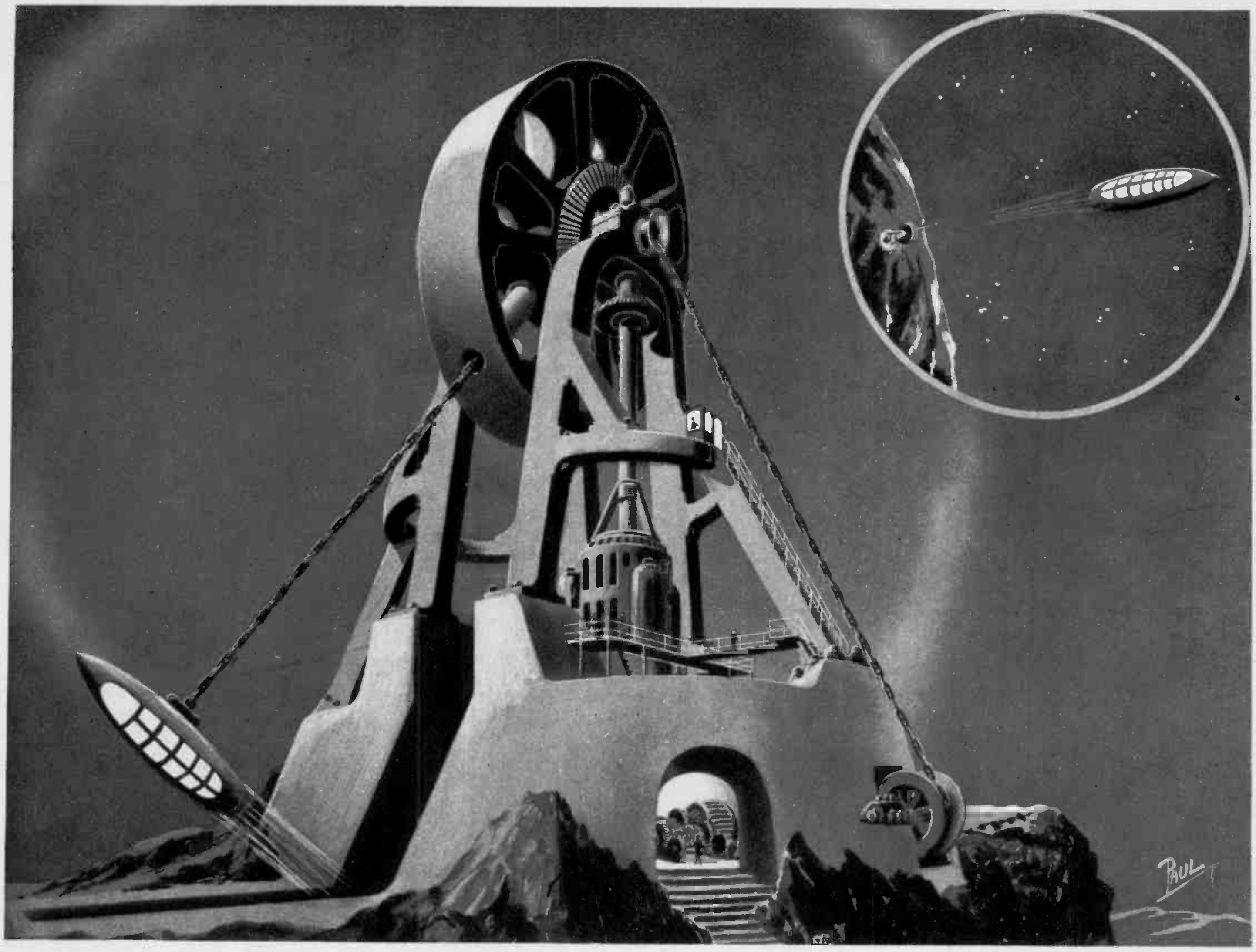
TUBBY LEARNS MORE ABOUT STARS AND ORBITS

"If I'm goin' to boss this expedition," he

(*Continued on page* 505)



The Great Mogul of Jupiter Was a Towering Giant Some Fifteen Feet Tall. The Audience With His Highness Was Held in Front of the Space Flyer as the Travelers Found It Difficult to Walk on Jupiter, Owing to the Great Gravitational Pull Which Increased Their Weight Considerably.



View of the Gigantic Machine Designed by Dr. Hackensaw for Projecting His Moon Car on Its Journey Away From the Earth. The Passengers Are Placed in the Car Itself, and As the Huge Wheel Is Rotated by a Giant Electric Motor, the Chain Is Fed Into the Hub of the Wheel and Causes the Radius of the Swing to Be Increased. When the Velocity of the Car Has Reached a Certain Point, It Is Suddenly Released and Leaves the Earth.

Doctor Hackensaw's Secrets

By CLEMENT FEZANDIÉ

(Author's Note. Will man ever be able to travel to the moon or to the nearest planets? The problem is one of perennial interest, and many fiction writers have attempted to solve it. Numerous fantastic schemes have been proposed, but I have endeavored to show in the following story that the sending of a passenger to the moon is by no means an impossibility).

No 20
A Car for the Moon!

"DOCTOR," said Silas Rockett, "Did I understand you to say that you intended to send a car to the moon?"

"You certainly did, Silas," replied Doctor Hackensaw. "The moon was in a condition to support life hundreds of thousands of years before the Earth. Hence there may be intelligent creatures on the moon with inventions far in advance of our wildest speculations. Think what it would mean to open communication with them and learning what it would otherwise take us a hundred thousand years or more to learn! It would be a triumph such as no man has ever achieved before me!"

"I understand that," said Silas, "but what I don't see, is how you are going to send your car of specimens to the moon. Many fiction writers have tackled the problem of communication with other worlds, but I confess that none of the methods I have read about seems to me to have any scientific basis. But tell me first, straight out, whether you really believe it is possible, at the present day, to send a car of any sort to the moon?"

"Not only do I believe it possible, Silas," replied Doctor Hackensaw, "but my conviction is so strong that for the past few years I have been secretly at work on the preparation necessary for sending a car full of specimens to the moon."

"What!" cried Silas in amazement. "You have already started making preparations for the trip? Is it possible that you have discovered some new force, some new means of locomotion?"

"No, Silas. The forces I shall use are all well known."

"But how in the world will you accomplish it? None of the schemes I have read about seems to offer the slightest possibility of being put into practice."

"What schemes have you read of?"

SILAS AND THE DOCTOR DISCUSS VARIOUS SCHEMES

"First of all there was the idea of being carried to the moon by birds. If I remember correctly, it was Cyirano de Bergerac who made the journey in that way. Such a method is of course impossible."

"True. No bird could fly to the moon. I'll admit that."

"Next, Edgar Allan Poe sent Hans Pfaal to the moon in a balloon. That, too, was impossible."

"I am ready to admit that also. Understand me; I am not a believer in the *ether* theory of light. Consequently I do not believe the heavens are filled with the so-called 'ether.' Nor do I believe there is an actual vacuum in space. My idea would be rather that there is a highly rarefied atmosphere between us and the planets. But, regardless of the question as

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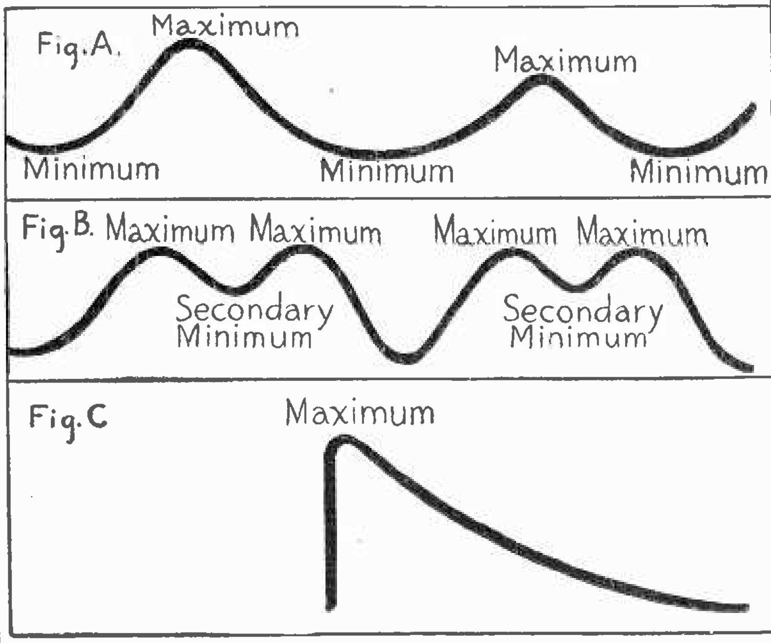


Fig. 1 Above Shows Light Fluctuations and Periods for Three Types of Variable Star. The Horizontal Distance Indicates the Period; and the Vertical the Light Range. Fig. A Is the Light Curve of a Long Period Variable (Class II). Notice How the Two Maxima Differ in Brilliancy. Fig. B Is the Complicated Light Curve of a Star of Class IV; and Fig. C, the Curve of a Nova.

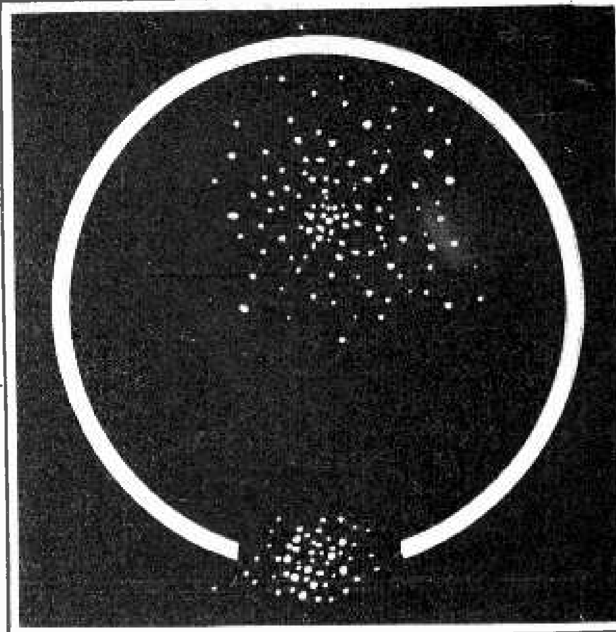


Fig. 2. Sir Norman Lockyer's Explanation for Long Period Variables. The Smaller Group of Meteors Travel Around the Larger, Which Is Situated Toward One Side of the Orbit. Periodically Collisions Take Place. Intense Heat Is Developed Leading to a Brilliant Conflagration.

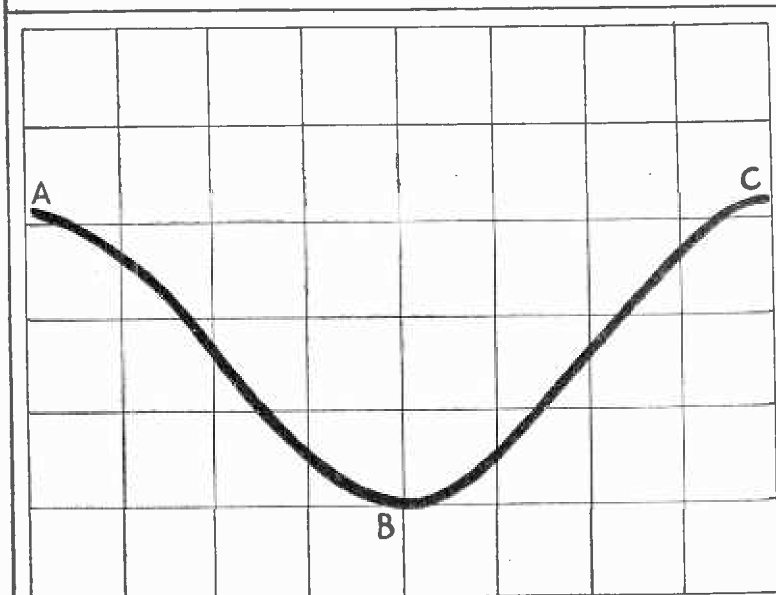
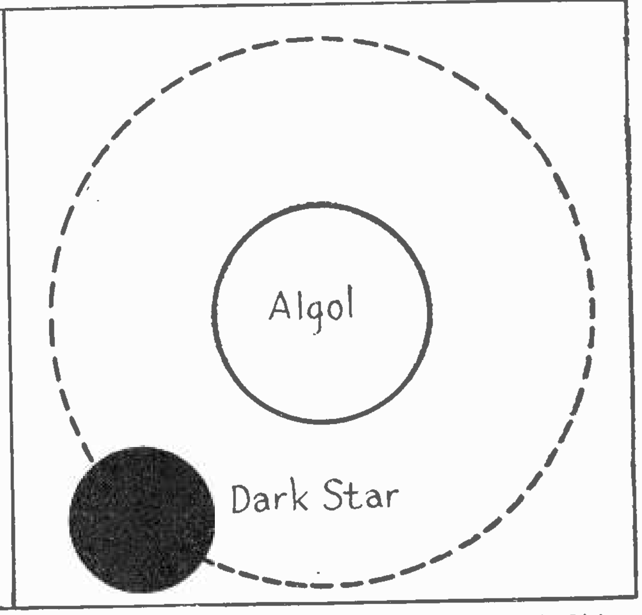


Fig. 3. The Light Curve of Algol, Which Is Typical of the Periodic Fluctuations of All Stars of Class V. From A to B Requires 4½ Hrs. From B to C, 3½ Hours. Minimum Lasts 20 Minutes.



Algol and Its Black Companion. The Fluctuations in the Light of the Former Are Caused by the Latter Periodically Passing Between It and the Earth, and Lessening Its Brilliancy.

Variable Stars

By RUFUS O. SUTER, Jr.

THE average person is little affected when he considers that if Aristotle should come to life today a casual observation of the heavens would reveal no change in the brilliancy of the stars. We have grown to look upon the sky as the paragon of constancy; but, as is often the case, we do not realize that this constancy is one of the greatest marvels which Nature presents. Every star is an incandescent mass so huge that if the earth were dropped into its seething depths, the catastrophe could only be compared to the dropping of a marble into a roaring steel-mill furnace. Nevertheless, each of these suns has poured into space for countless aeons, energy on the average amounting to 100,000 horse-power per square meter. Throughout the ages this unbelievable output has continued, undiminished and without fluctuation.

Fortunately, everybody does not regard matter-of-fact phenomena indifferently. Few discoveries would be made if this were the case, because curiosity often leads to the most successful investigations. Astronomers have been so impressed by the proverbial constancy of the stars that they have searched the sky for ages to find some exception. The ancients discovered the well known Algol, which undergoes fluctuations; and Mira, which every ten months drops from a luster rivaling that of the North Star to invisibility. Eighty years ago Argelander, the great German astronomer, catalogued eighteen stars which he believed were inconstant. Today scrutinizing observation has revealed that out of the 125 million stars visible through the most powerful telescopes, only 5,000 change in brilliancy.

Thus, peculiar as it may seem, irregularity of energy-production in the Sidereal Universe is the exception rather than the rule. These variable stars are a class by themselves, governed by laws with which we are largely unfamiliar. Professional and amateur astronomers the world over have united forces in obtaining systematic observations, with the hope that in time data enough may be secured to solve the mystery which surrounds them.

Observation already has revealed the fact that variables fall into five distinct classes:

1. The novae, or new stars, which sud-

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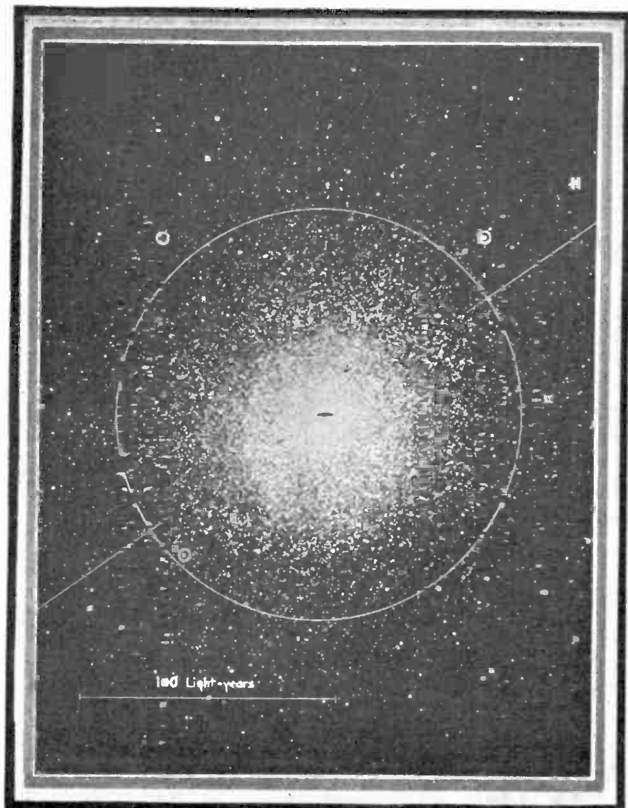
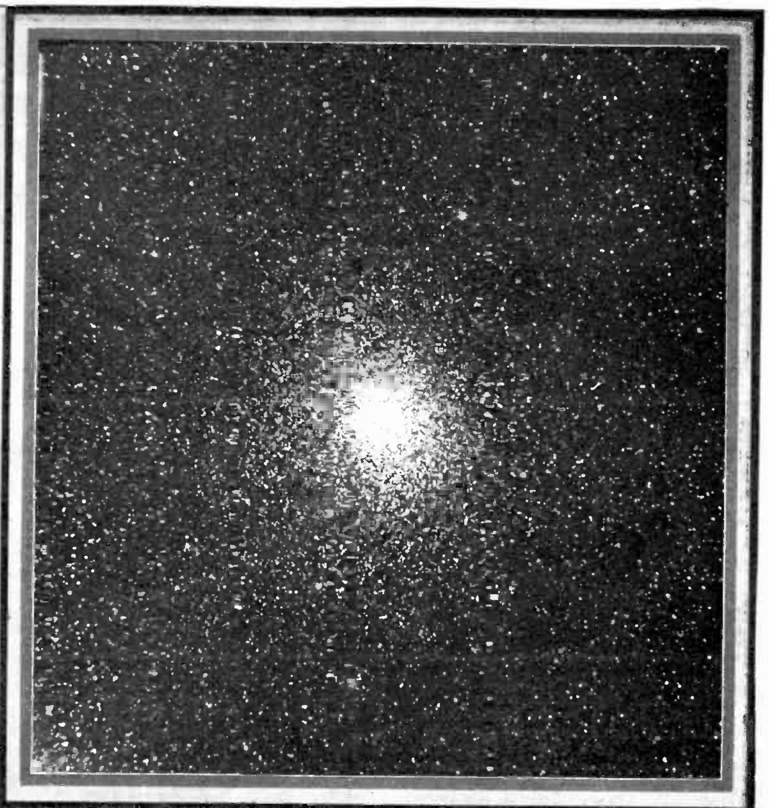
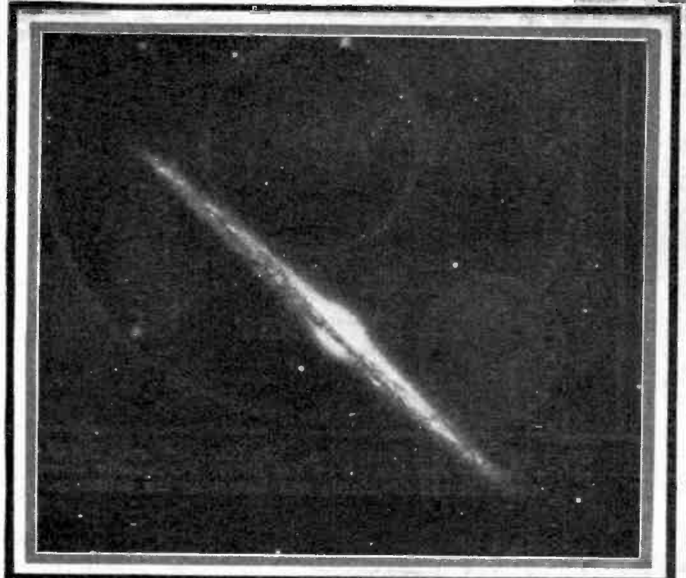


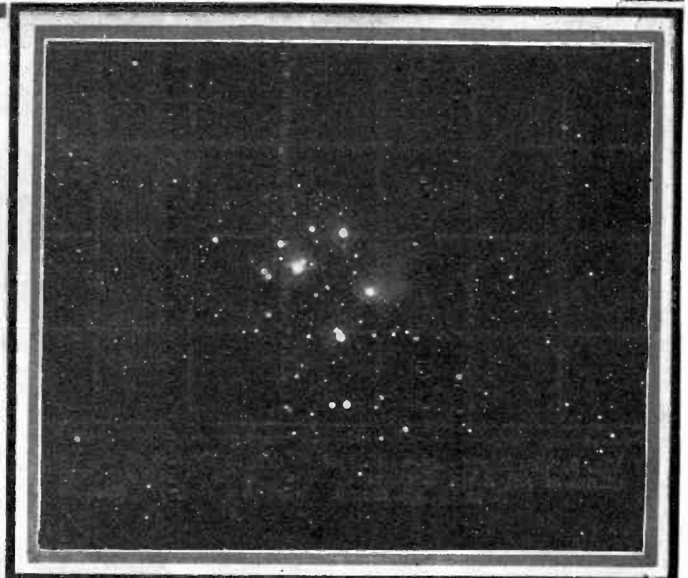
Messier 13, the Great Cluster in Hercules. The Small Black Line Indicates the Distance from the Center to the Nearest Star. The Hyades Would Be as Distant as the Star Marked H. The Circle Is 160 Light Years Across. The Stars in Small Circles Are 100 Times as Bright as Our Sun.



Messier 22, a Globular Cluster in the Constellation Sagittarius. It Contains More Than 50,000 Stars. It Is So Far Away That Its Light Must Travel Across Space for 27,000 Years Before It Reaches the Earth.



A Spiral Nebula, Seen Edgewise; In This Position the Nebula Is Often Called a Spindle. The Nucleus Is so Much Brighter Than the Material in the Spiral Arms That They Appear to Cross the Nucleus as a Dark Streak.



The Pleiades, a Well-Known Cluster in the Constellation of the Bull, Showing Nebulosity Around Some of the Brighter Stars.

Star Clusters

By BASIL NEWCOMB

OF THE HARVARD COLLEGE OBSERVATORY

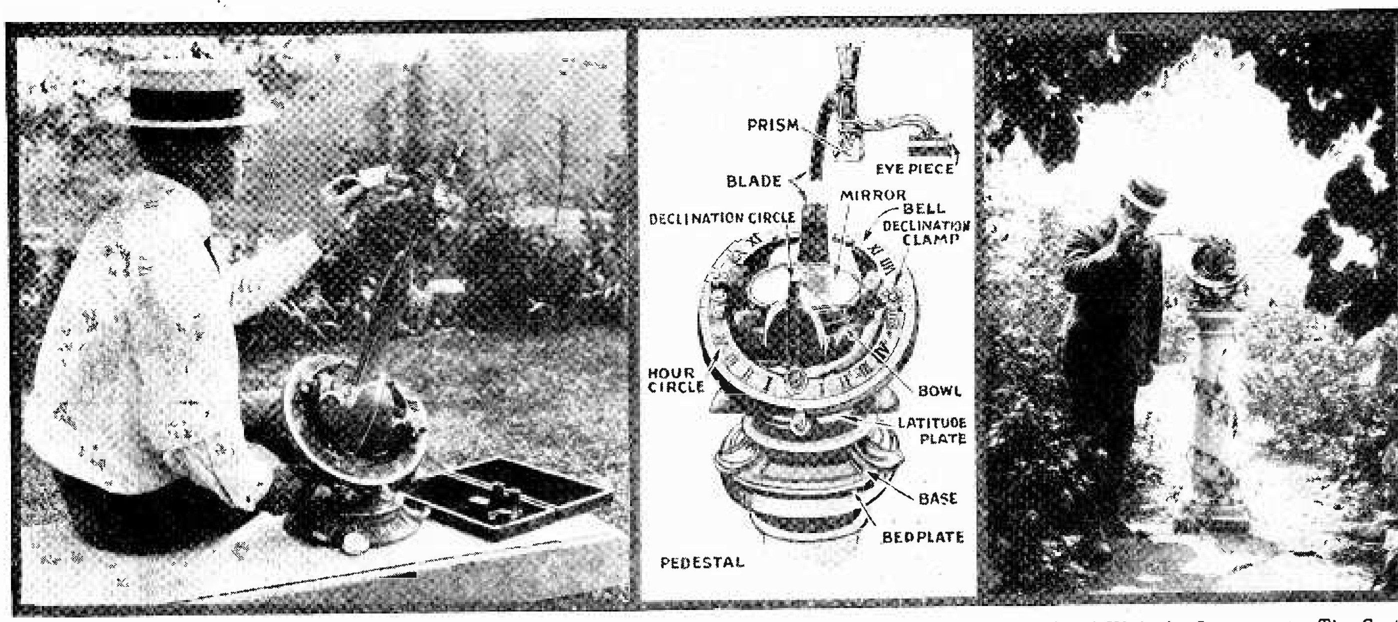
SINGLE stars, quite free from close alliances, are apparently not in the majority in our universe. Very frequently stars occur in groups of two and three. Sometimes a score or two associate together, and occasionally we find them in aggregations of a hundred thousand or more.

The ancients gave mythical names to the familiar groups of bright stars, and these constellation names are used to this day. But the constellations in general are chance and often imaginary arrangements; their stars are seen near to one another by projection only. The real grouping or clustering tendency mentioned above is something different. It signifies actual association in motion, origin, color and distance, indicating that the stars of any one group or cluster are physically related to one another.

A few constellations of the ancients, however, have been proved by modern research to be clusters in the true sense of the word.

(*Continued on page 498*)

High Power Telescope for Your Garden



A New Six-Inch Diameter High-Powered Reflecting Telescope Suitable For the Garden Or Other Locations Has Been Brought Out By An American Manufacturer. There Has Been a Long Felt Want For a Telescope of This Type Which Should Cost Neither Much Nor Little, But Be Capable of Fairly High Magnification. The Man At the Left Is Telling the Time By Focusing the Telescope On the Sun and Reading the Dial Settings, As Given In the Instruction Book Furnished With the Instrument. The Center Picture Shows Details of the Telescope, Including the Six-Inch Diameter Mirror, Reflecting Prism and Eye-Piece. The Right-Hand Photograph Shows How the Telescope Appears In the Garden and How Convenient It Is For a Person To Look Into the Eye-Piece, Which Is Placed At the Side of the Telescope.

THIS garden telescope is as useful by day as by night. It may be placed on the lawn on a pedestal, or may be set up on the porch for viewing distant objects. If the city dweller has a place available on his roof, it may be equally well placed there—on the verandas of summer hotels, in the mountains or on the shore—always ready for instant use. It requires no care—no more than would be bestowed on a garden sun dial. The mirror is a polished glass concave disk, silvered on its front surface, lacquered to protect its silver coat. The mirror is protected when not in use by a cast-bronze cover with machined edges that fit tightly to the mirror cell. The mirror always faces the object viewed and since the eyepiece can be moved around the end of the blade to any position, the observer may always be comfortable whether the object he is viewing is overhead or on the horizon. There are none of the back- and neck-breaking attitudes required in some positions of the common telescope.

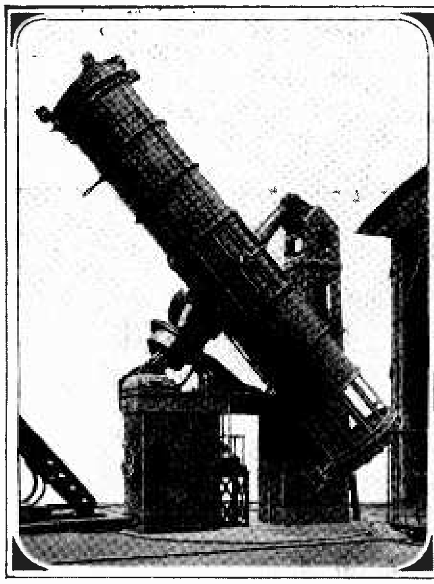
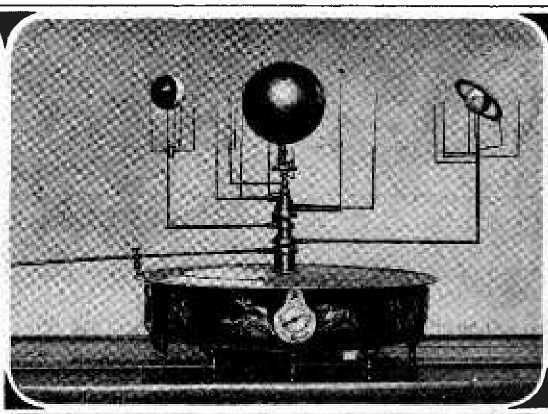
SIGHTING AND FINDING

On the back of the blade are two pointers, and these are used very much like gun-sights in picking up distant objects. When they are in line with the object, it will be seen in the eyepiece. They constitute a finder. For terrestrial use, then, the declination and base clamping screws are released and the telescope can be swung around and brought to bear on any desired object. No other adjustments are necessary. The mirror and eyepiece may be taken indoors, if desired, when not in use, for safe keeping.

The earth turning over on its axis gives the stars an appearance of moving across the heavens. To follow the stars, therefore, the telescope has one bearing parallel to the earth's axis, thus constituting what astronomers call an equatorial mounting. The other bearing of the telescope, the declination axis, which carries bowl, blade and telescope and it permits pointing or setting on any object in the heavens. A part of the bell is cut away to prevent interference with the blade in certain positions. This is shown clearly in the photograph above.

AS A TIME KEEPER

Like the sun dial, the garden telescope gives us sun-time, but with greater accuracy. One of the photographs indicates how this is done. The telescope is pointed at the sun, not by looking into the eyepiece, but by projecting an image of the sun on a card placed near the eyepiece. The sun-time is then read off on the hour circle on the rim of the bell. Watch or standard time may be found by consulting a table for this purpose in the booklet furnished with the telescope. If the house clock, or your watch, has run down, the time is thus readily recovered on any clear day. This garden telescope is a complete reflector. It comprises a six-inch parabolic silvered mirror of approximately two feet focal length, totally reflecting glass prism, with one-half inch E.F. positive prismatic erecting eyepiece giving fifty magnifications; solid bronze combination mounting.


Left: The Great Equatorial Telescope of the Paris Observatory Showing the Mounting Clearly. The Seat of the Operator Is Changed So As To Correspond With the Varying Positions of the Telescope. Above: A Planetarium Constructed In 1830, Now Property of the Paris Observatory. Right: A Reflecting Telescope Built In 1875 By Eichens. It Has An Aperture of Almost Four Feet.

The Paris Observatory

THE establishment of the Paris Observatory goes back to the days of Louis XIV. Richelieu originated it as far back as 1664, Colbert took it in hand, and it is curious to read that the object was to rival or to equal the observatories of England, of Denmark and of China. Claude Perrault, celebrated architect of the Louvre, put up the first building and work was begun upon it in 1667. Efforts were made to get the great astronomers of the world, such as Huyghens, Newton and Leibnitz, to come to the observatory. None of these would come and eventually Jean Dominique Cassini from the famous University of Bologne was put in charge, and three generations of Cassini's succeeded each other in conducting the observatory.

It is interesting to read about the old-time instruments of the eighteenth century. The telescopes were of small diameter with long focus lenses. For observations in the regions of the zenith, a building without a roof was used, and there was a long gap or slot made in the northern wall of the building for raising and lowering objectives to different heights. We are told that there was a wooden tower, which carried on its top an objective of two hundred and fifty foot focus. There was no tube and the astronomer at the base of the tower held the eye piece in his hand, remarkable dexterity being required to make observations under these conditions.

Of course, many discoveries were made in the observatory. It was there that the Danish astronomer Roemer determined that light required from seven to eight minutes to traverse the distance from the sun to the earth, really 8 minutes 20 seconds, basing his calculations on the eclipses of the satellites of Jupiter. In 1657 the catalogue of fixed stars was begun. In the latter half of the eighteenth century great activity obtained which was rudely interrupted by the French Revolution. Cassini the Fourth, as he was called, objecting to the treatment by the Convention, resigned on the day of an eclipse of the sun, September 6, 1793, and then had to put in six months in prison.

Mr. Jerome de Lalande was the Director of the observatory for some ten years following the Revolution, and he is said to have enjoyed great popularity and did good work. His great treatise on astronomy was used for several generations by students and is still consulted. A curious thing is told about his gastronomic propensities. He was very fond of eating caterpillars and spiders. Every Saturday he used to take supper with a friend, whose wife collected for his benefit a number of these disagreeable creatures and gave him a saucer full of them. He said that the spiders tasted like nuts, while the caterpillars reminded him of peaches or plums.

The great Arago figures among the workers on the staff of the observatory, concerning himself with geodetic operations, laying out the meridians during war time, which involved his being seized as a spy, and captured at sea by a privateer. He eventually reached Marseilles in 1809, after his mother had given him up as dead.

We finally come to Le Verrier. He was said to have been very unpopular, but won world-wide fame when he discovered the planet Neptune. He has been termed "the Giant of Modern Astronomy." Neptune, it must be remembered, was found by pure mathematical calculation, the data leading to its identification being based on the motions of other planets.

Many of the old-time instruments are still preserved in the Museum.

The regular work of the ever busy observatory constantly goes on, and the photography of the heavens has been completed at last.

Many special investigations, such as those of the satellites of Saturn and those of Jupiter with photometric investigations, had been carried on. By using polarized light and the spectroscope great differences in the luminosity of stars have been observed and have given the base for determining temperatures. Thus the temperature of the sun has been placed at 5,320° C., 9608° F.—far more than that of the electric arc—and these have coincided with other former observations in which polarization was not used. The temperature of one of the stars in Taurus is given at not less than 40,000° C., 72,000° F., in round numbers.

Time signals are sent from the station on the Eiffel Tower covering a great part of the world so that chronometers can be regulated thereby. These signals give time as determined in the observatory.

There are three clocks of the observatory kept in a crypt. The temperature practically never varies and the clocks are accurate to three ten-thousands of a second in a day. Sometimes no error can be detected. An astronomer can, by observing a star, determine time to one-tenth of a second, but the clocks of the observatory surpass him many times in accuracy. By methods at the disposal of the observatory the geographic positions of the principal points on the earth's surface are now being fixed. Our illustrations show some of the modern apparatus of the famous observatory and a famous old planetarium.

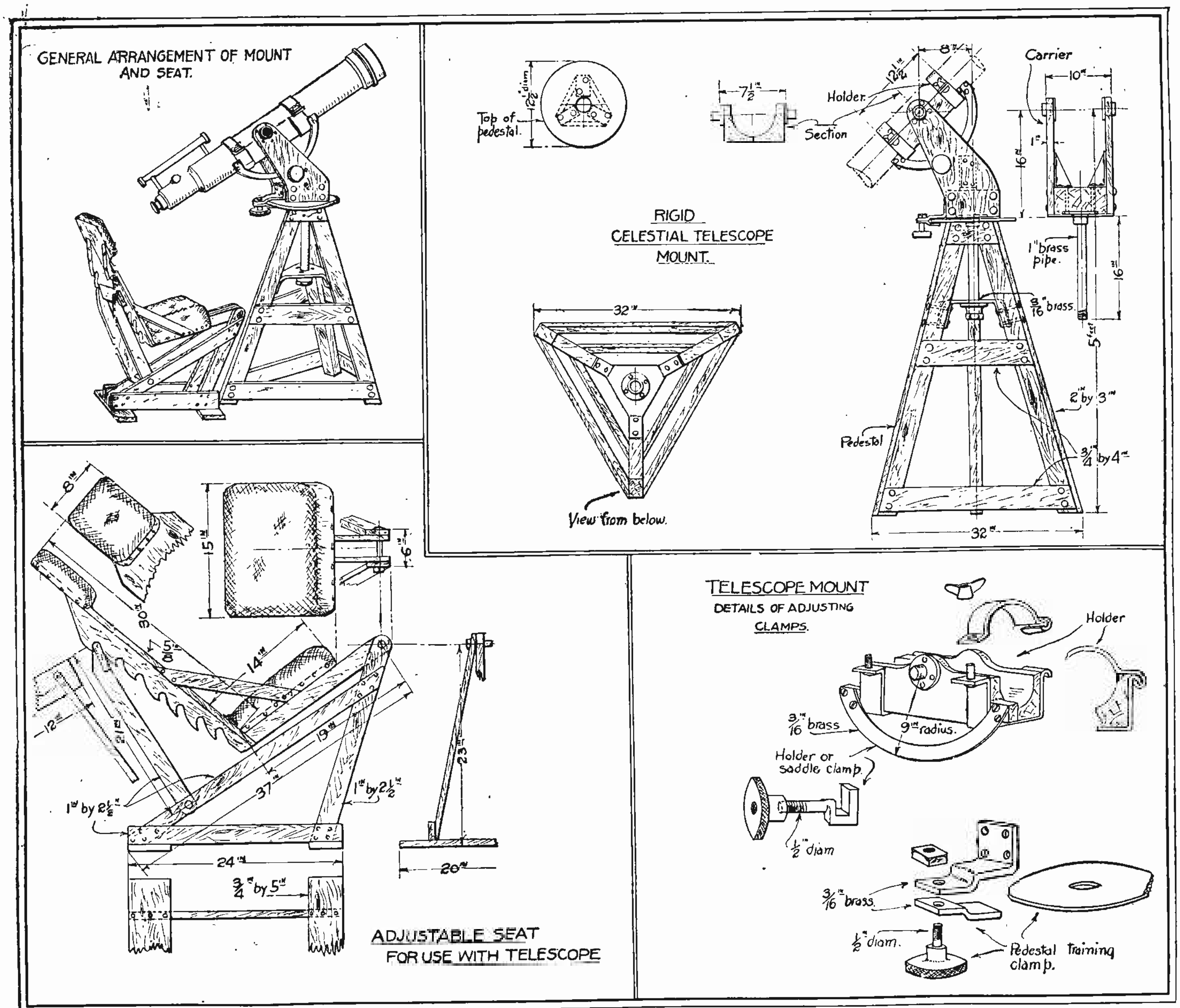
To Study Sun's Eclipse

The afternoon of Sept. 10 next a party of eight men, headed by Dr. John A. Miller of Swarthmore College and Dr. Heber D. Curtis, Director of the Allegheny Observatory, Pittsburgh, will gather at the tiny village of Yerbeniz, Mexico, to spend 189 seconds—the length of time the sun will be completely eclipsed by the moon—in important astronomical photography.

After journeying to Yerbeniz, which is near Cuencame, halfway between El Paso and Mexico City, the party will spend more than six weeks in setting up intricate and fragile apparatus, weighing more than two tons, which will be used in the making of the pictures.

The camp of the Sproul Expedition, as the party will be known, will be located at an altitude of 6,200 feet. It is the purpose of the expedition to obtain large-scale photographs of the sun's corona. In the equipment is a telescope sixty-five feet long. The Einstein theory will be attacked with a powerful pair of cameras, with lenses eight and a half inches in diameter, each with a focal length of fifteen feet.

Dr. Curtis built at the Allegheny Observatory machine shop an instrument for studying the spectrum of the sun in the "red" region, a thing never before attempted.



In the Upper Left Hand Corner Will Be Seen a View of the Finished Telescope Complete With the Mounting and Operator's Seat. The Upper Right Hand Illustration Shows the Constructional Details of the Rigid Mounting Used With This Telescope and the Lower Left Hand Drawing Shows the Details of the Seat. The Adjusting Clamps for the Telescope Proper Are Illustrated in the Lower Right Hand Corner.

A Rigid Celestial Telescope Mount

By GEORGE A. LUERS

THE mounting of a telescope for celestial observation is of utmost importance to obtain a decisive rigidity and avoid the disturbing flexibility, detracting from the exactness of observations.

The observer presses his head with a varying force against the eye aperture and any unsteadiness of the stand or the connections is transmitted as tremors or a flicking of the object across the telescope lens. The magnification of the telescope amplifies the movement and the unsteadiness of the mounting is a pronounced handicap to the observer. A perfect telescope inadequately mounted will give less satisfaction than a telescope with poor or faulty lens, that is supported with a proper steady pedestal with facilities for shifting the position of the telescope without decisive exertion of the observer while holding his eye steadily on the object. Obviously a jerky movement will carry the observer off the point, because of the limitations of the small field of high power telescopes. To lose the object is disconcerting and probably necessitates a long search that is annoying to the user of the instrument.

In this article a description with fully illustrated drawings for a telescope mount is given.

The construction purposely avoids expense of construction, through the use of available materials, mainly wood, however without sacrifice of the essential features for obtaining the desired stability and adjustment.

Assuming it is desired to mount a telescope of four or five feet in length with a magnification of one hundred to two hundred times, which instrument will meet the general requirements for a modest equipment, the adopted height for the tube of the telescope of five feet will afford the use of a seat for the observer, which detail from the point of time required in observations is essential to some degree of comfort.

The three legs of the tripod are secured with cross braces of lighter wood, while the upper ends terminate and are secured to a circular brass or steel plate. A triangular plate in the midposition serves jointly to brace the legs and as a section of the bearing.

The rotating part of the mount or carrier is also made of wood. A heavy block secures the pivot bearing, while side cheeks are fastened to this, using sheet metal brace plates, which side cheeks have at the upper ends trunnion bearings or bearings for the horizontal axis of the instrument.

A holder for the telescope is made in the form of a saddle, this part being provided with detachable clamps, for convenience in removing the telescope after use. The removable feature is important, as a telescope requires protection from the elements as far as possible. Moisture or sweating of the telescope is avoided by careful storage in a dry box or housing. Dirt and cinders on the lens will dull them through need of frequent wiping. Rain will frequently rust the adjustments inside the tube or make the bronze adjusters stiff.

The detachable saddle is made of wood, with sheet metal braces to hold this solid. Two trunnions or bearings are fitted to the sides for rotating in the horizontal bearing guides of the carrier. The clamps are of sheet metal bent to conform to the telescope.

Einstein's Restricted Theory of Relativity Explained On a Model*

By VLADIMIR KARAPETOFF

PROFESSOR ELECTRICAL ENGINEERING, CORNELL UNIVERSITY. RESEARCH EDITOR OF THE ELECTRICAL WORLD.

THERE are two questions in connection with the theory of relativity of interest to a layman, namely, (a) What is the theory of relativity in the specific sense of the word used by physicists? and (b) How do we know that this theory is true? The model shown in Fig. 1 aims to answer the first question. As to proofs of the correctness of Einstein's theory press dispatches have told us of astronomical expeditions which confirmed his theoretical predictions. Moreover, there are certain physical experiments and phenomena for which Einstein's theory furnishes the most satisfactory explanation. As time goes on, this theory will either be further established by additional evidence, or else new phenomena may be discovered not in accord with it. Our present problem is to learn to think in terms of this theory.

TIME ON THE MODEL IS REPLACED BY LENGTHS

The theory of relativity furnishes no new evidences at usual velocities which are small as compared to the velocity of light (300,000 kilometers per second). Even the velocity of our Army rifle bullet is less than 1 kilometer per second. Therefore, a model must be so designed as to show phenomena at very high relative velocities, say 10 per cent, 20 per cent, etc., of that of light. The solution lies in replacing time by distances. Everyone is familiar with this mode of representation of time. For example, fluctuations in the price of a commodity in various years are represented by a curve, we replace time (years) by a length (say 1 cm. = 1 year). With this substitution of distances for time, the model needs no parts revolving at practically impossible velocities. Since the velocity of light in vacuo is a physical constant of great importance in the theory of relativity, it has been selected in the model for units of both length and time. This means that a unit distance and a unit time are represented by equal lengths, and a material point which moves at our assumed velocity of light covers 1 unit distance in 1 unit time.

*The experimental part of the investigation upon which this article is based was supported by a grant from the Heckscher Foundation for the Advancement of Research, established by August Heckscher at Cornell University.

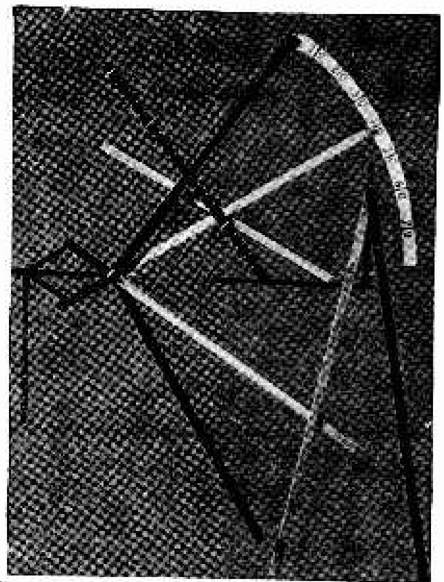


Fig. 1 Above Shows Model Constructed by Professor Karapetoff in Demonstrating the Various Phases of the Einstein Theory. School Teachers and Others Interested in Studying or Lecturing on the Einstein Theory, Will Find This Specially Written Article by Professor Karapetoff of Unusual Interest and Value.

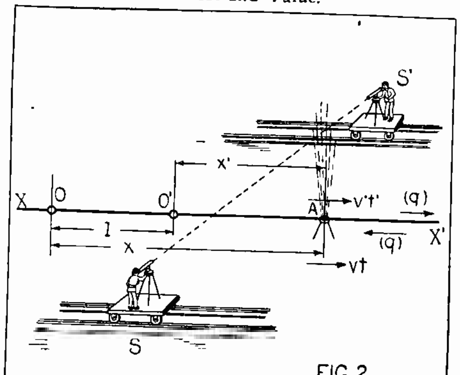


FIG.2

Fig. 2 Introduced Above, Shows Two Observers S and S' Who With Their Platforms and Instruments are in Relative Motion With Respect to Each Other, Along the Axis X X'.

THE MODEL MAY REPRESENT TIME-SPACE RELATIONSHIPS IN A DIFFERENT WORLD

In order to dodge completely the question as to whether Einstein is right or wrong, we shall simply say that the model shown in Fig. 1 represents the space-time relationships in an entirely different world, which may or may not be similar to ours. We shall make this world logical in itself and should we find that our conclusions, derived from the model, agree quantitatively with certain observed physical phenomena, we may be made to believe that the queer world, represented by the model, may be our own world after all.

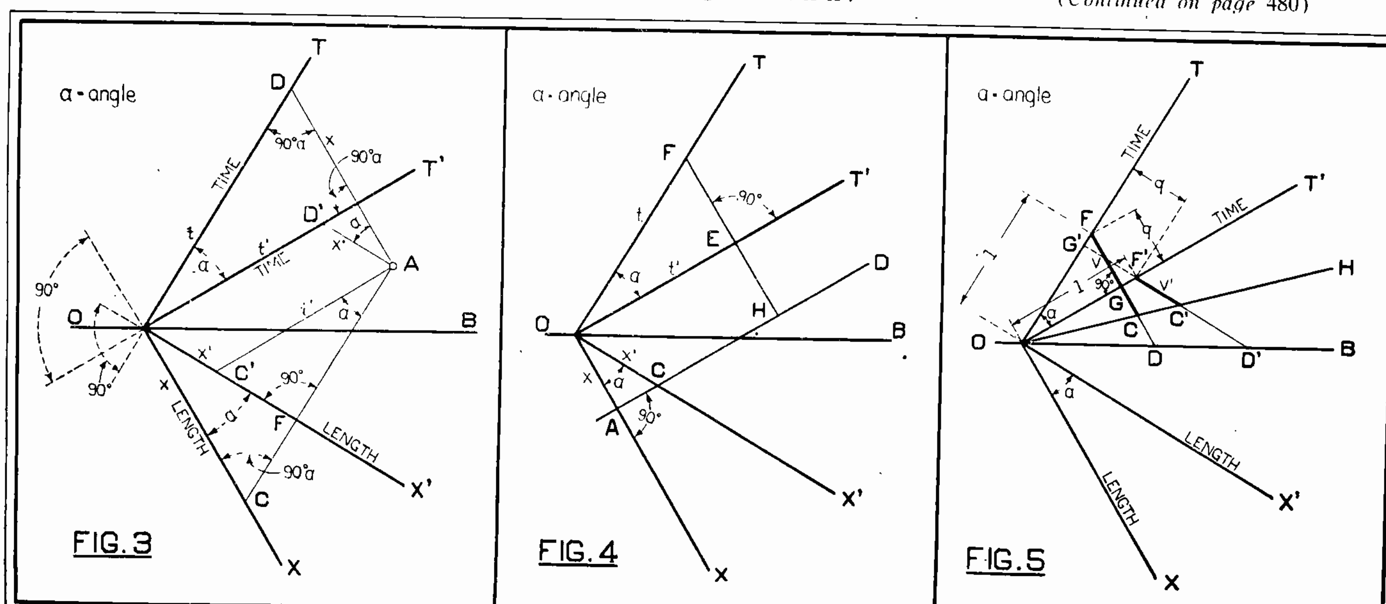
To make the conditions as simple as possible, we shall assume that in this fairyland all motion takes place along the same line XX^1 (Fig. 2) and that we have two observers, S and S^1, who with their platforms and instruments are in relative motion with respect to each other, along the XX^1 axis, at a uniform velocity q. This means that to the S observer (who thinks himself stationary) the S^1 system is moving at the velocity q to the right.

On the other hand, the S^1 observer considers himself stationary and to him the S observer with his platform and instruments appears moving to the left at the same velocity q.

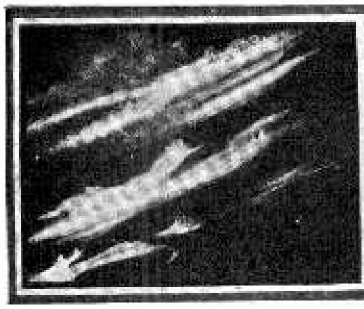
According to a fundamental postulate of relativity, there is no absolute stationary point of reference in the universe and all motion is relative. Hence, there is no logical contradiction in the foregoing views of the two observers. Furthermore, we shall assume that at some time the two observers were stationary with respect to each other and adjusted their standards of length and their clocks so as to agree to a very high degree of precision. Each observer has his point of reference (O and O^1) from which he measures his distances (x and x^1) along OO^1, and the clocks at O and O^1 are so set, that at the instant when O and O^1 coincide, both clocks show zero (say twelve o'clock).

Let A be an *event*, say an instantaneous flash of light, independent of both observers, and let each observer be asked to be prepared to watch for it and to find (a) the distance

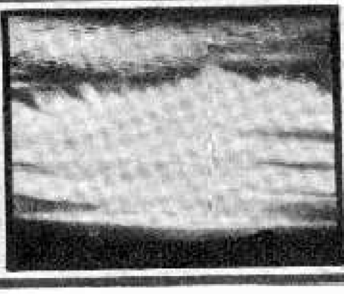
(*Continued on page* 480)



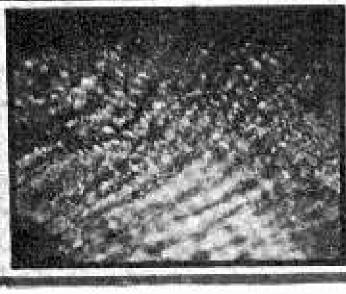
The Three Diagrams above, Figs. 3, 4 and 5, Illustrate Various Positions of the Graduated Rules or Sticks of the Model, Shown in Fig. 1 Above.



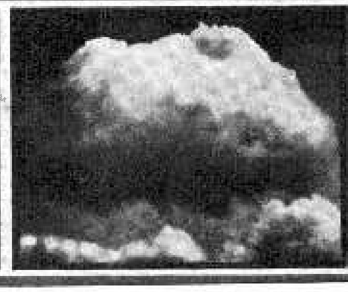
Cirrus Clouds Give Warning of Wet Weather Within Twelve to Twenty-four Hours.



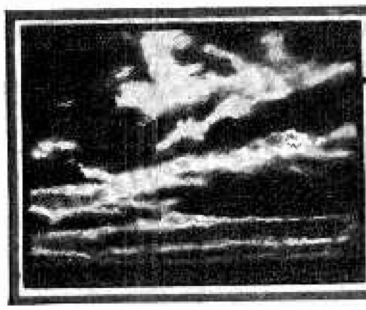
Cirro-stratus Clouds Usually Precede Rain or Snow.



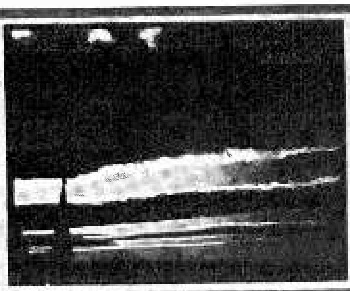
Cirro-cumulus Clouds Foretell Dry Hot Weather; If Edges Become Raged and Broken—Brisk Winds.



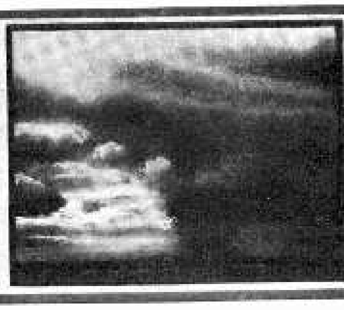
Cumulus Clouds—Fair Weather Indicators. They Also Precede Thunder Storms and Are Called "Thunder Heads."



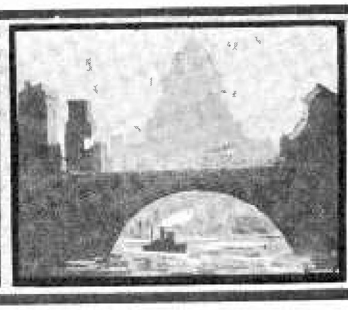
Cumulo-stratus Clouds Have a Threatening Appearance, But Are Really Heralds of Fair Weather.



Stratus—the Lowest of All Clouds—Which When Resting Over the Land Are Called Fog.



Nimbus Clouds, From Which Rain or Snow Falls.



Haze or Fog; the Ordinary Fog With Which Every one is Familiar.

How to Forecast the Weather

By E. B. "FARMER" DUNN

FORMERLY OF THE U. S. WEATHER BUREAU

CIRRUS clouds furnish one of the best means of foretelling weather changes. If the weather be fair, no change is likely to take place until these clouds appear. They give a warning of from twelve to twenty-four hours before wet weather sets in. They are the forerunners of all storms and move from a westerly or southwesterly direction, and from three hundred to five hundred miles in advance of the storm. If they move rapidly, the storm is approaching rapidly. If they drift along and the ends of their feathery whisps turn down, it is an indication that the weather is likely to continue fair, but if they turn up, rain or snow is to follow within twenty-four hours.

If they form in bands and lose their feathery appearance, it means high winds. If they form and dissolve, fair weather will continue for at least twenty-four hours. Cirrus clouds of "mackerel" formation foretell wind and rain and snow; with long streamers reaching upward, wind alone.

Cirro-stratus clouds usually precede rain or snow from twelve to twenty-four hours. They move from a westerly or southwesterly direction; the same direction from which the rain or snow or general storm centre is coming and are usually accompanied by high winds.

A mottled sky, with light drifting clouds, foretells fair weather.

Cirro-cumulus clouds are termed "fair weather clouds." In Summer they foretell dry, hot weather. When their small tufts merge into one another, several days of fair weather are due.

Cumulus clouds are considered fair weather indicators, but when they appear the day is generally warm and sultry and the clouds form during or shortly after the hottest part of the day. They are, also, the clouds that usually precede thunderstorms and are called "thunder heads."

They start close to the horizon with a low, flat base and grow and expand steadily into the upper air without the least sign of local storm development. They gradually rise higher and higher and become well rounded masses with beautiful domes. Then, if thunderstorms are to develop, there will appear fine, feathery Cirrus clouds distinctly separate from the Cumulus clouds. Soon the Cumulus will turn a dark gray and grow darker as they come nearer. From beneath the Cumulus cloud will shoot out a small, dark, threatening cloud which will rush forward with a great burst of wind and sometimes rain.

If wind comes before the rain the squall will be of short duration. If rain comes before the wind it may last an hour or two. The heavier the rain the quicker the squall passes.

Cumulo-stratus clouds form in the lower air strata. They assume something of a Cumulus formation, with a flat, extended base and a partially rounded, but ragged, broken top. They are Winter clouds and appear in cold, dry weather. They have a dark, threatening appearance, but are really heralds of fair weather. They dissolve in late afternoon or warmer part of the day.

Stratus clouds are the lowest of all clouds and, when resting over the land or water, are called fog.

When fog sets in before midnight the following day is likely to be rainy, but if fog appears in the morning after sunrise, the day will be fair.

Nimbus clouds are those from which rain invariably falls. They are without complete definition; a broken, confused mass being driven by the lower easterly winds.

A general increase of cloudiness at sunset means rain or snow.

Tufts of cloud forming a dappled or mottled sky indicate fair weather.

A fog, arising in the morning is the surest sign of a fair day.

Small, inky clouds indicate rain.

In cold weather, a bank of dark cloud forming in the north or west with a southerly or easterly wind indicates rain or snow.

An excessive clearness of the atmosphere is an indication of rain or snow to follow within twenty-four hours.

A low, overcast sky, with light northerly wind in Winter, foretells snow.

Ragged clouds moving rapidly indicate wind and rain.

Dew indicates a fair day. Wind or cloudy nights prevent frost or dew.

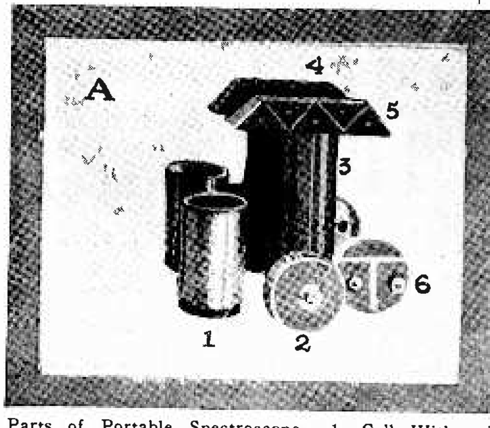
A yellow sunset foretells rain; a bright straw yellow, wind and rain, and yellow blending into orange, fair weather.

A red sunset, a fair day.
A red sunrise, a wet day.
A gray sunset, a wet day.
A gray sunrise, a fair day.
Dark Indian gray sunrise or sunset, rain.
Pale green at sunset, rain.
Combined green and red sunset or sunrise, probably rain.

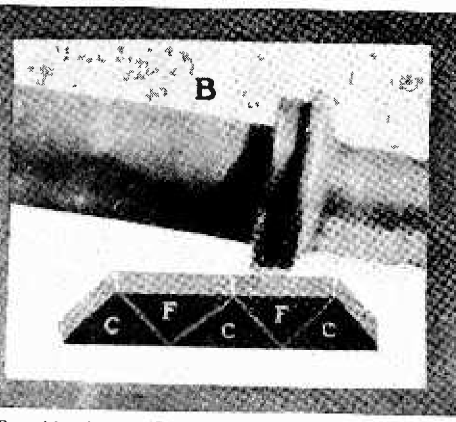
A red disc at sunset means fair and warmer.

Cool wind over a warm surface or water, or a warm wind over a cool surface or water creates fog.

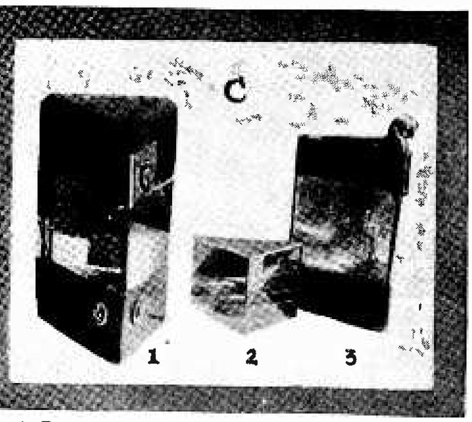
Sudden fall in temperature causes showers.
Sudden rise in temperature, fair weather.
High temperature and high humidity, thunder-storms.



Parts of Portable Spectroscope. 1, Cell With Achromatic Lens; 2, Eye Cap; 3, Prism Tube; 4, Top; 5, Prism Series; 6, Adjustable Slit In Collimator Head.



Portable Hand Spectroscope Adapted To the Ocular System of a 4″ Refractor. For Solar and Stellar Observation. C, Crown Glass Prisms; F, Flint Glass Prisms.



1, Dense 60° Flint Prism Mounted; 2, Borosilicate Crown Right Angle Prism; 3, Fluid Prism Made of Three Thin Lantern Slides and Filled With Carbon Disulphide.

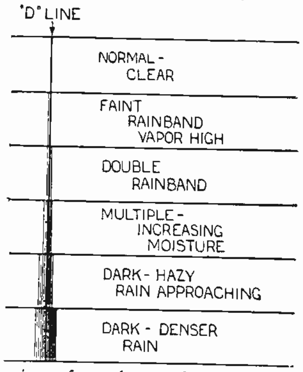
Spectroscopes--How to Build Them

By C. E. BARNS

ONE of my apt pupils in reflector-building wrote me that when he first looked into the eyepiece of his instrument and saw the belts and moons of Jupiter, the rings of Saturn, the nebula of Orion and the crater of Copernicus, his wife thought he had "gone plumb crazy with joy!" First glimpses through a telescope upon which you have expended much time and labor give a thrill of delight not soon forgotten. But it remains for the spectroscope to absolutely dazzle one with a new world of mystery and beauty;

MAKING THE PRISM

A borosilicate 60° prism suitable for a table-spectroscope will cost some twelve or fifteen dollars; but the novice has two alternatives: the purchasing a two-inch blank



p ism for about three dollars and grinding and polishing it himself, or the constructing of one of three evenly matched pieces of thin clear negative glass by binding and cementing together with acetic glue so as to be absolutely water-tight, and filling with distilled water, or, better still (at least so far as the increased refractive and dispersive powers go), with carbon disulphide. In the latter case the prism should be well capped and corked, as this chemical is not only volatile and malodorous, but inflammable If, however, this fluid prism is thoroughly cleaned with a solution of caustic potash distilled water affords a very interesting spectrum. Various liquids may also be examined in a fluid prism.

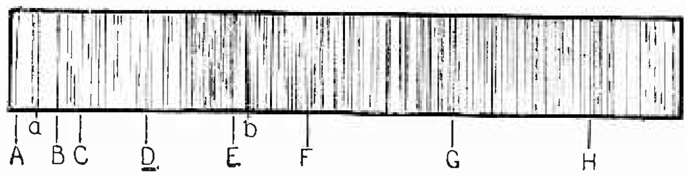
REQUISITES OF A TABLE-SPECTROSCOPE

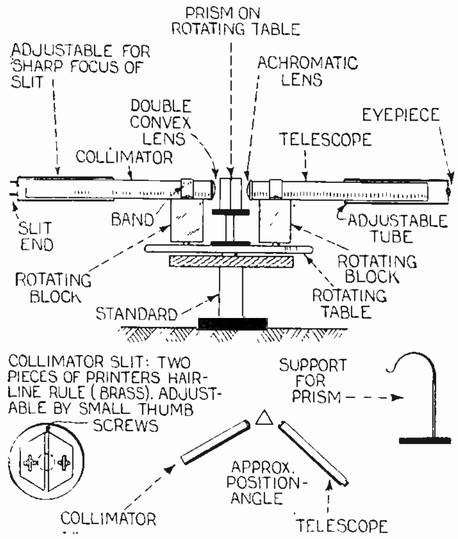
The three requisites in a table-spectroscope system are: the prism, the collimator with lens and slit for producing the spectrum, and the telescope for viewing the same. The length of the collimator-tube should be approximately the focal length of the double-convex lens used to magnify the image of the slit at the other end of the tube; and it is well to have the slit-device on a separate adjustable tube so that a clean line of light cuts the prism, is refracted and dispersed, and the emergent beam taken up and magnified by the telescope system placed at such an angle as will insure a sharp view of the famous Fraunhoefer lines. When pointed at the sun, these cut through the brilliant bands of color parallel thereto in myriad profusion. But, as the prophet saith "the hairs of your head are numbered," so science has numbered and annotated every line and combination of lines in that vast orderly array—"the alphabet of the physical universe." Every one of the ninety-two known elements gives a distinct and separate spectrum, from hydrogen, the lightest, to uranium, the heaviest, in atomic weight when made incandescent in laboratory research and yet all are there in one combined solar blaze! It is well worth while to build a spectroscope just to behold this one amazing phenomenon.

The length of your tubes for collimator and telescope will depend upon the focal length of the double convex lens in the former and of the achromatic lens used in the latter system. It is well to have sliding ends to both so that accurate adjustment is possible—that the slit may cut a sharp image on the prism surface and the telescope take it up sharply beyond. Usually when the telescope is first focused upon some distant object, this is sufficient adjustment, but success depends largely upon a cleanly magnified image of the slit which is seldom more than a hair-line in width. The brighter the source of light the narrower the slit, so that it is necessary to have the jaws adjustable with set-screws in the collimator head. Any printer will supply you with a few inches of new hair-line brass rule which has almost a razor-edge and is even throughout. With this rule the jaws may be made, crossing the center of the hole in the collimator head, which should be small, not over three-eighths of an inch for a one-inch lens at the prism end, nor over three-quarters of an inch for a two-inch lens. This is the size I use with great satisfaction.

The blocks upon which the telescope and collimator are fixed should be bolted to the circular table with a single center bolt so as to turn at will. The prism should be mounted upon a separate circular table that not only turns from right to left, as occasion demands, but is also arranged so that it may be raised or lowered; for you are likely to try out prisms large and small—crown, flint, dense flint and fluid—and the matter of accurate adjustment is of great importance. An arm extending over the top of the prism will anchor it to the table in case you wish to tilt the system so as to catch the direct rays of the sun, for instance. In that event the jaws of the slit should be drawn together so that they almost touch. A moistened toothpick swept the length of the slit will keep it free from dust, else your spectrum will be imperfect.

On the Left is Shown the Method of Forecasting the Weather By the Aid of the Bright Telluric Bands Near the "D" Line of the Solar Spectrum. At the Right the Spectrum and Its Various Lines Are Illustrated In Detail.





Details For the Construction of a Table Spectroscope Are Given In the Drawing Above.

USING THE SPECTROSCOPE

With such a table-spectroscope not only may the solar spectrum be examined with success, but the study of spectrum analysis may be undertaken with confidence. A Bunsen burner, spirit lamp or even a gas-jet turned very low (so as not to produce its own spectrum) may be employed to vaporize various chemical salts and so produce their individual spectra—for instance, salts of lithium, calcium, sodium, strontium, barium,

(*Continued on page 483*)

Man and the Stars

By J. S. DOW

M R. J. S. DOW of London, England, who is the author of this article, has delved deeply into the infinite. He has treated the infinitely small and infinitely large in a manner, that will be intelligible to everyone. The topic and its treatment follow the lines of some of our Editorials that have appeared in past issues.

Is there an ULTRA-WORLD and an INFRA-WORLD?

The present article will suggest answers to this two-fold question.

—EDITOR.

IT is surely one of the strangest illustrations of the absorption of men in their own small affairs that most people are content to pass their lives without learning to identify the different stars, and are without curiosity as to the nature of the planets and the fixed stars. My own interest in the subject was awakened by the chance gift, as a prize at school, of Sir Robert Ball's popular work on "The Story of the Heavens." I was aware that the distance of the sun from the earth approached a hundred million miles. But it was a revelation to discover that Sirius, the most brilliant star in the Heavens, is roughly a million times as distant as the sun. I was equally impressed by the discovery that our own solar system, apart from the rotary motion of the earth on its axis and its course round the sun, is moving through space at a gigantic speed—that "every three days the solar system accomplishes a stage of about two million miles on its journey towards the constellation Lyra." Fortunately the distance of Lyra is comfortably great—so great that even at this express speed the journey would take at least a million years!

Is there any study more rich than astronomy in romantic discoveries and predictions? Is there anything in science more impressive that the prediction by Halley of the transit of Venus, which he knew he could not live to see, but which he foretold to the minute and commended to the attention of posterity? Again, can one imagine a coincidence (for it can have been nothing else) more strange than the account of the moons of Mars in Gulliver's Travels, (published in 1726). It was narrated that the astronomers in the Island of Laputa had keen vision and very powerful telescopes and had detected *two* moons of Mars. Now this was just 150 years before the existence of two moons of Mars, was ascertained, with great difficulty, by Professor Hall. These two moons have most curious properties. Having escaped detection for so long they are naturally small objects, only about 18 miles and 22 miles respectively in diameter. Interest attaches chiefly to the inner of the two satellites, which is only 4,000 miles distant from Mars, whose bulk must render it invisible during 2/3 of its period in the most favorable circumstances; it is never visible at the poles. The most singular thing about this inner moon is that, whereas Mars, like the earth, rotates on its axis in about 24 hours, the period of revolution of this moon is only 7 h., 40 min.—a circumstance believed to be unparalleled in the solar system and quite unforeseen by astronomers. The rapid motion of this moon would be evident to an inhabitant of Mars; it would in fact appear to travel visibly like the clockwork driven moons occasionally seen on the stage. Strange to say in Gulliver's Travels this singular short period of one of the moons was also predicted, the period being given as about 10 hours—a remarkably close guess!

It is also interesting to observe how often scientific discoveries, apparently only of academic interest, eventually prove to have a direct and practical bearing on human affairs. Our knowledge of the constitution of distant suns is derived chiefly from the spectroscope which enables us to identify arrangements of spectral lines characteristic of known elements. Thus we have learned that most of the familiar terrestrial metals are present in the sun. Not only this, but the spectroscope enabled the existence of a new element, helium, to be detected in the sun before it was known to exist on our earth. It is related that when a popular lecturer was enthusiastically decribing this incident, a voice at the back interrupted the proceedings by the bored inquiry "Who *cares* whether there's helium in the sun or no?" Ultimately, as is now well known, helium was discovered by Sir William Ramsay as a minute constituent in the earth's atmosphere, isolated with great difficulty and in very small quantities. Afterwards it was discovered that helium could be produced on a commercial scale from certain natural gas in Canada and the United States. Shortly before the Armistice sufficient was accumulated to fill the envelopes of airships with this "rare" gas, which had the great advantage over hydrogen of being non-inflammable.

One picturesque possibility that has arrested the attention of writers of fiction is the sudden arrival in our solar system of a strange planet. Mr. H. G. Wells has written a story in which the consequences of such an invasion are graphically told. Some concern was expressed in the daily press a few years ago at the birth of a new star in the Heavens whose growing brightness led to the conjecture that it was moving rapidly towards the earth. If such an approach of a planet ever came to pass, the Astronomer Royal would become the most important expert in this nation. True he could do nothing to ward off the catastrophe, but he might be able to predict the probable course of events, and at least inform us of the period which was to elapse before serious trouble would be experienced. The immense distance from which such a foreign earth would probably have to travel is a comforting circumstance. Speaking generally it would appear that any incipient or threatened invasion of our solar system by a body, large enough to have any material effect, would be, in its initial stages, a very gradual process.

The study of the stars confirms the agelong philosophical conception that time and space are only modes of thought—that to someone in a larger scheme of existence our terrestrial distances are as naught, and a few thousand years of the earth's history but a flash of time. Throughout the universe dimensions of time and distance correspond. As we have to deal with larger bodies and greater distances traversed, so the period of time increases and demands larger units. This was most vividly illustrated a few years ago in a work by Mr. E. Fournier d'Albé, who contrasted the motion of the planets round the sun, with the similar motions, on a far more minute scale, of the electrons that circle round the central nucleus of the atom. The conception of an atom as the smallest particle of matter has of course been greatly modified since the acceptance of the electron theory. We now know that an atom is itself a complex system. To us the period of revolution of the electron round the atomic centre appear infinitesimal, the distance of the electron from the nucleus round which it revolves exceedingly minute. This small scale of magnitudes he named the "infra-world."

But may there not exist also an "ultra-world," to the inhabitants of which our times and distances would seem as infinitesimal as those in the infra-world appear to us? This leads to a new conception of space for which there seems to be some scientific justification. One is prone to imagine that space is occupied by constellations scattered at immense distances and more or less regular intervals, and this condition continues indefinitely as space is extended. But the greater refinements of modern astronomical observations suggest that this is not the case. Apparently there exists an outer void where no more constellations are found but merely untenanted space. It may therefore be conjectured that our universe is merely an isolated system, separated from other similar universes by distances immensely greater even than those dealt with in ordinary astronomy. We are thus led to the conception of an ultra-world comprising a multitude of universes—each forming an object as minute in this ultra-world as are the atoms of our own earth. We may also picture an "ultra-ultra world", in which the ultra world itself becomes a minute, almost infinitesimal object, and indeed an infinite succession of such worlds, each but a small object in the next greater.

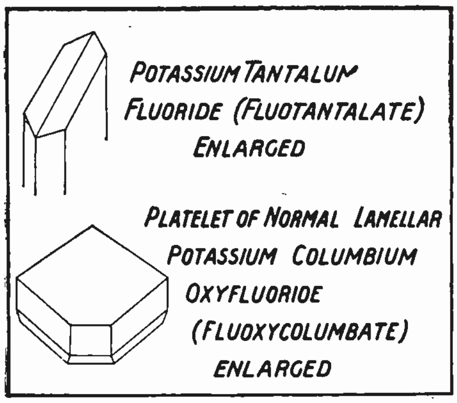
Another ingenious speculation of Mr. Fournier d'Albé may be recorded. We, on this earth, can control and rearrange the atoms. When we perform a chemical experiment atoms enter into new combinations and their life as elemental mocules comes to an end—that is sudden, according to our notions of time for the change appears to take place practically instantaneously. But to an inhabitant of the infra-world the change would not seem sudden at all. It would be a gradual process spread, perhaps over many "centuries" of the infra-scale of time. Similarily in the ultra-world we may conceive a Power bringing about changes in our universe executed in a flash of ultra-time but in our eyes proceeding so slowly as almost to escape detection. The "end of the world" then would come to us, not as has been commonly supposed, like a flash of lightning, but as a slow and almost inappreciable change, which is yet merely a momentary incident to the ultra-intelligence responsible. Here again, curiously enough, there seems to be some scientific justification for this conception of the end of the world. Possibly, therefore, in these minute changes we have the first faint indication of the final destiny of our universe.

Tantalum--All About It

By O. IVAN LEE, B.Sc.

FOREWORD

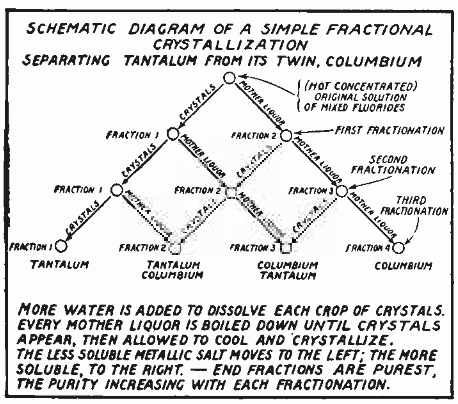
THE Great War focused the attention of the world upon the transscendent importance of the rarer metals and was reflected in the feverish activity to find and produce them so as to confer their marvelous virtues upon alloys for military purposes, ranging from lathe tools to armor plate. Today, tungsten, molybdenum and vanadium are almost household words. But tantalum is a stranger to most of us. Your pragmatic chemist friend may recall with some effort that it is indeed a rare metal—of some academic interest—but will shake his head if pressed for details by the curious. No, he doesn't know what it looks like, and it isn't good for much anyway!



Above Is Shown the Striking Difference In the Appearance of the Salts of Tantalum and Columbium, By Means of Which the Former Is Purified.

Because of the difficulties inherent in its production on a commercial scale in a pure state, metallic tantalum has remained a laboratory curiosity, and little has been available except occasional foreign material of fluctuating composition and variable properties. As a consequence, metallurgists and chemists have had but limited opportunities to explore the possibilities offered by an adequate supply of this remarkable metal.

After several years of intensive experimenting under the capable direction of Dr. Balke, practical results have been attained and ductile metallic tantalum of great purity is now an industrial reality. Noteworthy results have already been attained, but the technical world is convinced that far more interesting results lie "just around the corner."



The Above Chart Shows the Simple Fractional Crystallization Which Occurs When Separating Purified Tantalum Salt From Its Neighbor Columbium Salt.

HOW TANTALUM WAS MADE KNOWN TO THE WORLD AND HOW IT CONFOUNDED THE EARLY CHEMIST

It was in the year 1802 that the Swedish chemist Ekeberg announced that while endeavoring to unravel the nature of a queer black mineral from Kimito, Finland, he encountered most discouraging obstacles in his efforts to get it into solution. The metal assumed to be present, although resembling tin, tungsten and titanium, was yet none of these, but a new element, "because even in the midst of acid it was unable to take the liquid to itself." In playful allusion to these *tantalizing* difficulties, he named the novel substance "tantalum" from that legendary unfortunate, Tantalus, whose thirst, you recall, was only exceeded by his inability to quench it.

Tantalum

THE accompanying article by Mr. Lee, well-known analytical chemist, describes the occurrence, mining and the latest methods of refining tantalum, one of the rarer elements which bids fair to enter the field of industry to an extent not dreamed of heretofore. Pure tantalum is one of the heaviest metals introduced into commerce, being 16.6 times as heavy as an equal volume of water, or half again as heavy as lead. It posseses a very high resistance to corrosion, and may be used in the place of platinum for many purposes including jewelry, laboratory utensils and standard weights.

The melting point of tantalum is more than a 1000° C above that of platinum. This astonishing new metal is unaffected by the king of solvents, aqua regia, which dissolves gold and platinum. Tantalum is readily made very ductile and can be rolled or drawn into rods, sheets or wire. It may be lead through and sealed in glass like platinum, having the same coefficient of expansion as glass. A tantalum electrode with a lead or other electrode placed in an electrolyte solution, results in an ideal rectifier for converting alternating to direct current, the tantalum electrode lasting indefinitely.

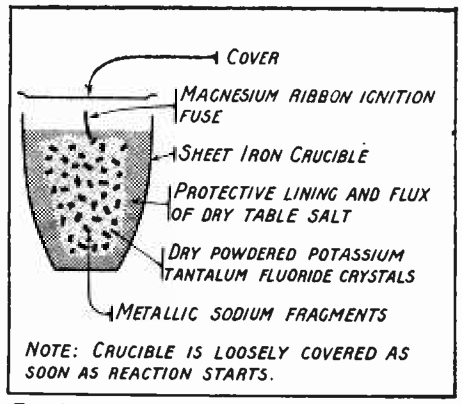
By a new process commercial tantalum of a very pure quality is now available, and it can be used for making non-rusting pens, fine tools, surgical and dental instruments and jewelry. In the electrical field tantalum promises to find considerable use as filaments for special lamps and radio vacuum tubes, for use in electric heaters and resistance furnaces, for leads in glass lamp bulbs, for grid and plate electrodes, in radio and X-ray tubes, lightning arrestors, electrolytic condensers, as well as for anodes and cathodes, for deposition of metals, such as silver, copper and gold. When alloyed with other metals it yields some very interesting and valuable results.

TANTALUM MINERALS AND ORES; WHERE THEY ARE FOUND.

Today some thirty different mineral species are known to contain tantalum to a noticeable degree, but the great majority of these are merely of scientific interest and found only in public and private mineral collections.

They occur principally in granite rocks, the economically important ores being limited to a scant three or four, and of these, only tantalite is continuously utilized as a source of raw material, particularly the variety manganotantalite.

Although of infrequent occurrence, tantalum ores are comparatively abundant in certain favored localities.



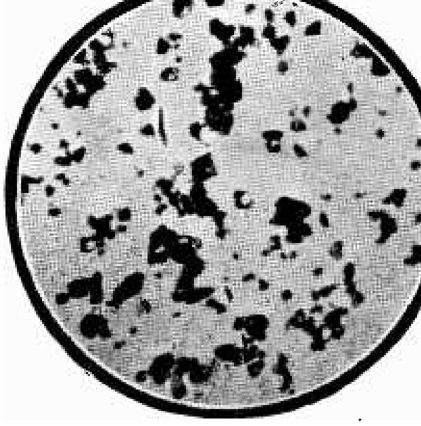
The Arrangement For the Laboratory Production of Metallic Tantalum.

Sixteen pound crystals of columbite, often associated with tantalum, have been found in Little Namaqualand, South Africa; pieces of samarskite up to twenty pounds have been found in the Wiseman Mine, North Carolina; in the Indian mica mines, the same mineral occurs, some pieces weighing several hundred pounds; seven miles west of Cañon City, Colorado, columbite is stated to have been found in large masses up to six hundred pounds; in the Bad Lands of South Dakota, similar deposits weighing a ton, and rich tantalite is relatively common in the tin-fields and gold fields of Western Australia. The tantalite from the Antipodes as a rule runs higher in tantalic oxide than the American, averaging 60% as against 25% for our native ore.

It would seem likely, too, that the mixed radioactive minerals now mined in Madagascar should yield tantalum as a by-product.

NATURE'S EXTRAORDINARY PARALLEL

Most amazing of all the tantalum minerals, is *native metallic tantalum* whose discovery was announced in 1909 in gold washings in the Ural Mountains of Russia. It is a



Microphotograph of Native Tantalum. (Enlarged 500 Diameters.) Courtesy of P. Walther.

bright greyish-yellow minutely crystalline powder analyzing 98.5% of tantalum and 1.5% of columbium, and is probably the rarest of all naturally occurring metals. A year later, it was also reported from the Altai Mountains in Mongolia, lacking columbium but with a trace of gold. One cannot avoid speculating how such material came into existence—whether it represents a minute survival of primeval tantalum which gradually became degraded to the multitudinous tantalum minerals, or whether nature, in a confidential mood, threw out this little hint just to encourage man in his efforts to duplicate her feat. The suppression of columbium only deepens the mystery.

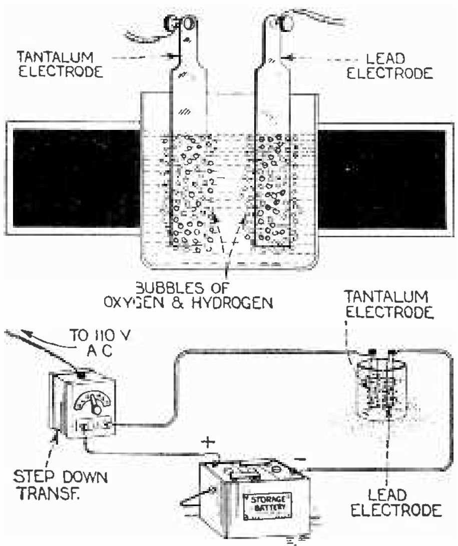
THE PIONEER PRODUCTION OF METALLIC TANTALUM

Even before the compound nature of the acid resistant material obtained from tantalite was recognized, attempts were made to isolate the metallic "tantalum" from it, in fact, almost one hundred years ago, Berzelius described the first product of this character made from potassium "tantalum" fluoride by reduction with metallic potassium, which process was then a comparatively new weapon in the chemists' hands. Needless to say, the "tantalum" thus produced was a very crude material and anything but metallic in appearance, being merely a black heavy powder which judging from its low specific gravity (10) contained only about 60% of metal. Nevertheless it was a beginning to have produced anything with tantalum in it, and although the properties of this substance were a miracle of divergence from what we know of tantalum today, yet it gave the world some conception of what might ultimately be expected.

MODERN METHODS OF MANUFACTURING TANTALUM

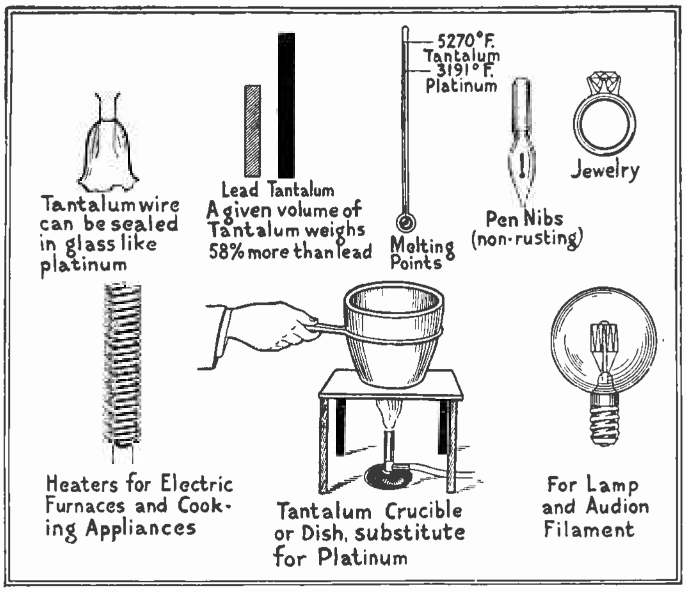
The method just described is still of more than theoretical interest, inasmuch as with certain modifications it may be utilized for making a product of genuine value. The cheap metallic sodium is substituted for the expensive metallic potassium, the tantalum salt being alternated with layers of small pieces of the sodium, in an iron crucible, the whole being topped with ordinary table salt, which, melting from the heat of the reaction, serves as a protective covering. The reaction is started by heating strongly at one point, but once on its way, requires no further aid, and the sodium burns vigorously.

On cooling and digging out the contents of the crucible, a porous grey material is found, interspersed with beautiful violet colored crystals of salt, sparkling like little amethysts. Unfortunately, they soon fade on exposure and disappear on contact with



The Method of Using a Tantalum Electrode In An Electrolytic Rectifier In Charging a Storage Battery.

Some of the Many Uses of the Metal Tantalum Are Shown In the Illustrations At the Right. Tantalum Will Take the Place of the More Expensive Platinum and Gold In Many Cases and One of Its Greatest Features Is That It Has the Same Co-efficient of Expansion As Glass. Therefore, It Can Be Sealed Into Glass Vessels In a Similar Manner To Platinum. It Also Has An Extremely High Melting Point, Being Much Higher Even Than Platinum. When Alloyed With Other Metals, It Presents Some Interesting Results.



water. As fragments of unconsumed sodium are apt to be present, the precaution is taken of first destroying this by covering the contents of the crucible with denatured alcohol until disintegrated. When the bubbling has ceased, the residue is very thoroughly washed first with water, then with a mineral acid and water again. In this way, salt and other soluble impurities are eliminated and the tantalum is left as a dense heavy black powder. In spite of the protection afforded by the molten salt, much of the tantalum finds an opportunity to combine with the air since tantalum easily unites with both oxygen and nitrogen; and it is the presence of these omnipotent gases which renders the tantalum made as just described impure and valueless. The great importance of excluding air was under-estimated by many of the pioneer workers with tantalum, or rather, the extraordinary power possessed by hot tantalum of absorbing or combining with inert and even reducing gases, was not realized. On this account it is more satisfactory and practicable to exclude any and all gases *by carrying out the whole operation in a vacuum.* The powder thus produced looks like that made by the old procedure, but in reality is far purer. It is now strongly compressed and heated, and finally melted in a vacuum at the high temperature of the electric furnace. This last treatment not only consolidates the metal, but expels any slight remaining impurities, resulting in tantalum at least 99.5% pure. Such material is capable of being drawn into fine wire, rolled into thin sheets and taking a mirror like polish.

This great advance in the art of producing useful tantalum was announced in 1905 by Dr. Von Bolton, head of the chemical laboratory of the great German electrical firm of Siemens and Halske. Simultaneously, the incentive was revealed with a description of its successful use for electric lamp filaments, in line with the general theory that that filament would give the best economical results which could be maintained for the longest time at the highest temperature. Although eventually superceded by the more efficient tungsten, these lamps have the low energy consumption of between 1.5 and 2.5 watts per candle power. In passing, it is well to remember that a pound of tantalum would make many thousand lamps, so that primarily von Bolton's feat may be taken as marking an epoch in quality rather than quantity production.

The more intricate problem of quantity production was ultimately mastered in 1922 by the Fansteel Products Company of North Chicago, the purity being greatly enhanced at the same time.

We may now well consider in some detail the very unusual physical and chemical properties of this recalcitrant metal whose devious history we have traced to the goal of making it an article of commerce. It is not often in these days that a metal of such novel characteristics is offered to the world, and still less frequently that it is of an elementary and distinctive nature, and not simply a clever hybrid of metals already well known and which consequently partakes a little of the qualities of each. It is fundamental to understand, then, that pure tantalum is as individual as gold, copper, lead and nickel and not a shifting alloy like brass and bronze, and exhibits peculiarities never before realized in any metal.

THE REMARKABLE PHYSICAL AND CHEMICAL PROPERTIES OF DUCTILE METALLIC TANTALUM

In appearance, tantalum resembles tool steel and platinum, the resemblance to the latter being so close that there is little doubt that it could be substituted in jewelry without the wearers ever being aware of the difference. For economic as well as sentimental reasons, however, it is doubtful if tantalum will ever become popular in this rôle. A thin sheet, when rolled and polished, has all the rigidity of hammered platinum foil. It is a comparatively hard metal, too, and in the purest state unites the hardness of the best medium steel, with a greater toughness and ductility than is known to be possessed by any other metal. Moreover, it can be drawn, rolled, beaten and in general worked by the same processes used with other metals.

Wrought tantalum is one of the heaviest metals ever introduced to commerce, being 16.6 times as heavy as an equal volume of water, or half again as heavy as lead. This coupled to its resistance to corrosion, has suggested it as being well adapted for standard weights.

Although the melting point is over 1,000 degrees Centigrade higher than that of platinum, it does not remain unaffected to the same extent on heating. At 400 C. the metal becomes blue, at 600 C., greyish black, and at still higher temperatures slowly oxidizes and burns. Towards chemical action, on the other hand, it is almost equally resistant although in divergent ways. It is attacked by hydrofluoric acid and mixtures containing this acid, but against this drawback we may balance the astonishing fact that *it is quite unaffected by "The King of Solvents," aqua regia*, which readily dissolves platinum. This renders it very suitable for the determination of gold and platinum by electrolytic deposition since they may thus

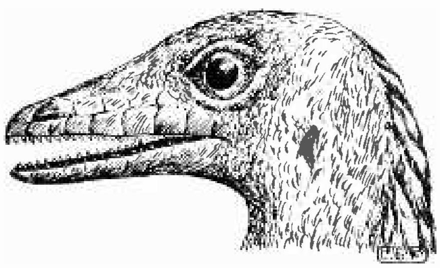
(Continued on page 499)

Birds That Had Teeth

By CARROLL LANE FENTON

Dept. Paleontology, University of Michigan

FIFTY million years or so ago, during the Cretaceous or Chalk period of the earth's history, much of North America was covered by broad, shallow seas that were dotted with low and almost barren islands. And upon these islands nested some of the



The Head of Archeopteryx, the "Father of Birds," Showing His Sharp Teeth.

strangest of all the thousands of odd creatures that have lived in past ages—birds that could not walk, and that had long beaks armed with sharp teeth.

These birds, like the other beings of ancient times, are known from their skeletons, which have been preserved and turned into stone in the chalk beds of western Kansas. These chalks once were muddy oozes lying at the bottom of the old sea. Whenever one of the birds died, and its bones sank to the bottom, they were covered by the ooze, and so preserved from destruction. They lay there for millions of years, while the sea disappeared, and the mud became solid rock. Today they are dug up by the collectors in the service of museums and universities, shipped hundreds or thousands of miles, and carefully taken from the rock which surrounds them. Then they are studied by paleontologists, and finally the bones are set up in as nearly as possible the attitude which they had during life.

Hesperornis, the *western bird*, as this ancient dweller of Kansas has been called, measured nearly five feet from the tip of his beak to the tip of his toes. In shape he was a good deal like the black and white Loon, or *hell diver* of modern rivers and lakes, but unlike that bird, he swam by means of his legs and feet alone, never trying to use wings. Indeed, he could hardly have done so, for after ages of disuse, his wings had disappeared entirely, and there remained but a few bones to show where they once had been.

But Hesperornis did not suffer any on this account, at least while he was in the water.

At the Right Will Be Seen the Hesperornis, the "Western Bird" on the Shore of an Ancient Kansas Island. This Bird Shows Distinct Teeth as May Be Seen.

His stout legs and paddle-like feet were all he needed to get about, either on the surface or below. Probably he swam lazily along until he saw a fish, and then, with a turn of his powerful feet, dived after it like an arrow. His body was shaped like a submarine, while his neck had the driving force of a heron's. Once a fish was caught in the bird's long beak, with its backwardly directed teeth, it had no chance to escape. It was swallowed promptly and Hesperornis went back to search for other victims.

However, the speed and grace of this toothed fisherman deserted him when he went ashore. His body was so long, his legs were placed so near his tail, and his feet were so perfectly fitted for swimming that he was out of place except in the water. Probably he could sit erect, even though with some difficulty, but for him to move about was almost out of the question. The very best he could do was to lie flat on the ground and wriggle awkwardly along with his legs sticking out behind. Anyone who has watched the clumsy twistings of a seal out of water can form a fair idea of the way in which Hesperornis must have moved. It was very fortunate for him that the little Cretaceous islands held almost no flesh-eating animals; had they done so the life of Hesperornis would have been very short, had he been able to exist at all.

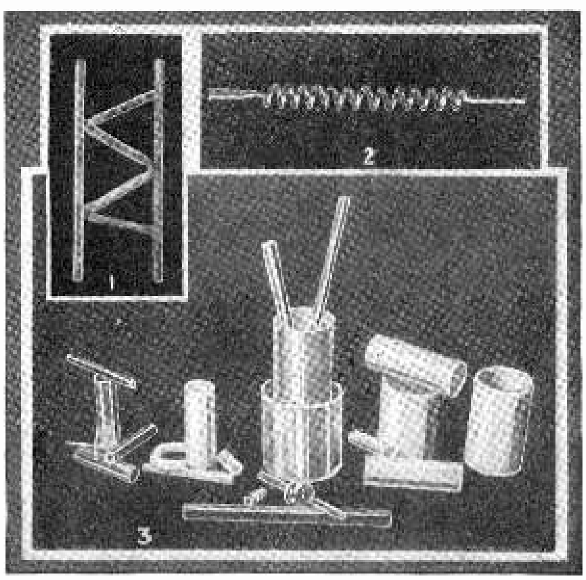
Although Hesperornis was the first bird *known* to possess teeth, he was by no means that first one that *did*. A few years after the remains of the *western bird* were collected in this country, a second skeleton of the most ancient bird of all, the *Archeopteryx*, was found, and it too had teeth.

Unbreakable Glass of the Future

MODERN researches for a hard but unbreakable glass really began in the year of 1774, when de la Bastie began to cool red-hot glass slowly and produced glass by his method which could be thrown violently to the ground without breaking. Another sort of glass has the quality of resistance to abrupt changes of temperature.

There are two sorts of quartz-glasses, the one the product of rock-crystal, the real transparent quartz-glass; the other untransparent, the product of rock-flint. Melting pots, tubes, clubs, flasks, refrigerators, evaporating basins, different fittings for electrical purposes and many other products for electric lighting are made of it.

The most remarkable quality of the quartz-glass is its very small coefficient of heat expansion, it only amounts to 0.00000059, in different words: whether one heats quartz-glass extremely—or whether one cools it extremely—it barely expands or contracts. Practically its size remains the same. Such glass can be heated red-hot and dipped while red-hot into cold water without cracking. It is this quality which has helped it to such ready admission into the technical and chemical laboratories. Besides



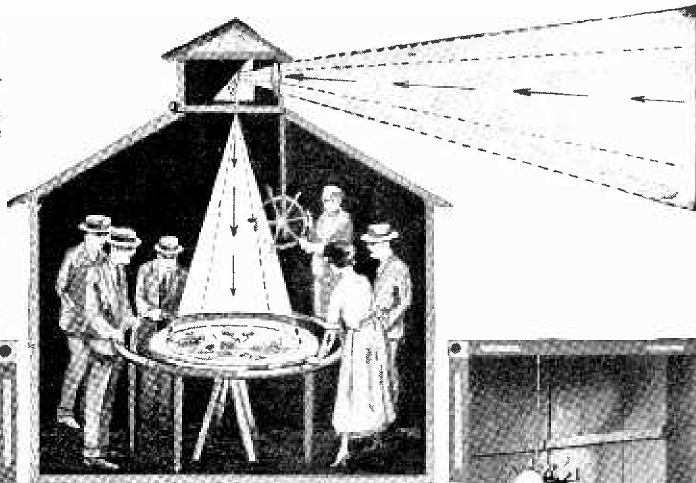
In the Photographs at the Left, 1, Shows a Triangle for Chemical Purposes, 2, a Tube in Serpentine Form and 3, Various Sizes of Glass Tubes. All of These Objects Are Made of a Difficultly Breakable Glass.

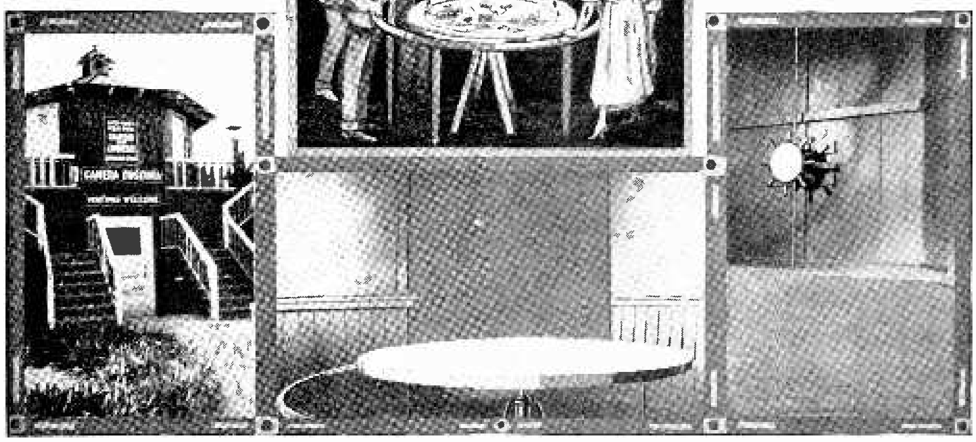
this it shows still quite a number of valuable qualities: the firmness of quartz-glass against breaking amounts to 12 kilogramme per square millimeter compared to 4.9 kilogramme for porcelain and 1.0 to 4.0 kilogramme for ordinary glass.

DR. ALBERT NEUBERGER.

Camera Obscura for Public Use

By LEWIS YEAGER





The Diagram In the Upper Center Shows the Camera Obscura Operator Directing the View Point, While the Three Photographs Below Show Various Portions of the Apparatus Necessary. The Lower Left Hand Photograph Shows An External View of the House Containing the Camera Obscura.

THE elaborate camera obscura at Santa Monica, Calif., is maintained for visitors and has an ideal location. The instrument requires sunshine and scenery and it is surrounded by both. The construction of the camera obscura is founded on the fact that the rays of light, when focused on a plane either by being passed through a small hole or by a converging lens, form an image of the objects from which they originally proceeded.

This may be readily tried by piercing the shade of a dark room with a small hole, and holding a piece of white paper within a short distance of it. It will be noticed the smaller the hole the more distinct is the image.

The discovery of the camera obscura is credited to Porta and strange as it may seem this places it as far back as the seventeenth century. Porta found that if the opening were filled with a convex lens the arrangement would make the image more distinct and far more brilliant.

HOW THE CAMERA OBSCURA WORKS

For those who do not know the application of the principle other than seen in the camera we include the following description:

Camera obscura means a dark chamber. As the name implies, it is a closed space from which the light is excluded. There is, however, a small aperture which admits rays of light. The rays proceeding from external objects, and entering by this aperture, form on the opposite side an image of the objects in natural colors.

Since it is often convenient to have the image produced upon a table the lenses are sometimes placed above the structure. To elucidate:

A brass case is at the peak of the roof which is conical or pyramidal as a rule, and this case holds the lenses. A triangular prism, which may be cut so as to act as a condensing lens separates a mirror set at 45°—one of the faces may be plane and the other may have such curvature that the combined refractions on entering or emerging from the prism produce the effect of a lens, while the flat side reflects the rays vertically downward on a table.

Those desiring to erect a camera obscura are advised to experiment with lenses and mirrors before finally constructing the parts for the structure.

A visitor at the Camera Obscura at Santa Monica, said to be one of the most complete in the world, and maintained at public expense, enters by a door which is closed after him. This leaves one in a six cornered dark room a dozen feet in diameter.

The roof of the room is peaked and at its center is the lens which can be rotated so as to point in any direction desired. One does not look in every direction at the same time as the lens only gathers the image from one direction.

One of the visitors turns a wheel arrangement connected by rods and a bevel gear to the lenses in the peak of the roof. This turret turns in any direction. The room is absolutely dark.

The sun then reflects a beautiful image in natural colors on the circular screen which occupies a position in the center of the room. The table may be tilted as desired. Not a detail of a breaker on the shore or of a motor car coming down the street is lost if the sun is bright. The colors are natural and no painter could duplicate the ocean scene, the waving palms, the palisades, the mountains in the distance or a thriving city street scene.

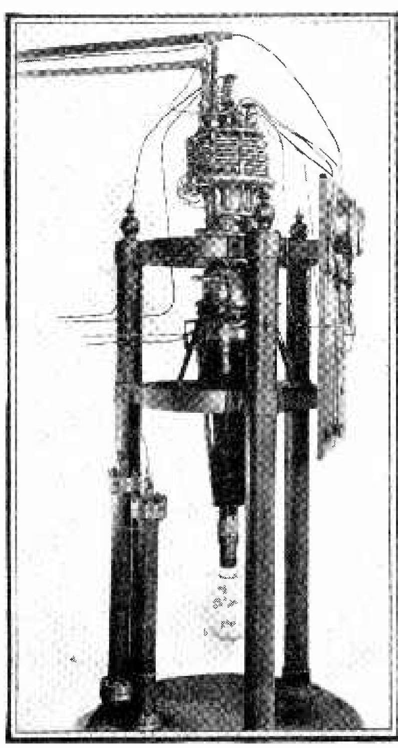
Liquid and Solid Hydrogen in Quantity Production

By S. R. WINTERS

HYDROGEN — the lightest substance known—is now being transformed into both liquid and solid states in quantity production. This is not a new scientific achievement of itself, but Dr. C. W. Kanolt of the Low Temperatures Laboratory of Uncle Sam's Bureau of Standards at Washington, D. C., is probably the first person in the world to devise a method whereby gaseous hydrogen may be converted into a fluid and a solid dependably and in any desired quantity. Two liters of liquid hydrogen may be manufactured each hour without experiencing much difficulty from clogging of the machinery, and the fluid can be readily changed to a solid by rapid evaporation of the liquid in a partial vacuum.

The apparatus for transforming this colorless, tasteless, and odorless gas into a fluid and, subsequently, to flakes resembling snow or ice, is essentially a

(*Continued on page* 493)

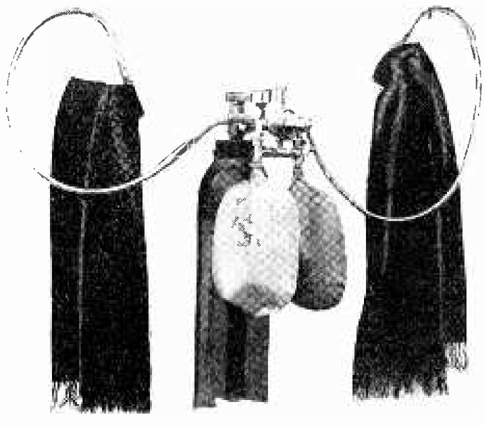


The Apparatus At the Right Is For the Production of Liquified and Solidified Hydrogen. Below Is Shown Dr. C. W. Kanolt of the United States Bureau of Standards With a Tube of Liquid Hydrogen.

Oxygen Apparatus for Mountain Climbers

By DR. ALBERT NEUBURGER

At Left: The New Oxygen Mountain Climbing Apparatus In Use. This New Oxygen Breathing Apparatus Will Make Successes of Mountain Climbing Expeditions Where Heretofore Failures Have Been the Rule. Below: The Apparatus For Inhaling Oxygen From a Single Cylinder.



THE story of the attempt of the English expedition to climb to the summit of the highest mountain of the world, Mount Everest, tells how these alpinists used oxygen, which they inhaled in the higher regions. In climbing to the 5,000 meter altitude, oxygen has not yet been used, though its inhaling would often have given great advantage. At a height of 3,000 meters the air is so rarefied and contains, therefore, so little oxygen that many people have suffered from lack of it. The vital forces diminish, the heart has to work harder, and people very often suffer with the so-called "mountain-sickness," whose symptoms are nearly the same ones as those of sea-sickness. After the experiences of the Mount Everest expedition proving the advantage of the use of oxygen, for without inhaling it the climbers never would have reached the height of 8,268 meters, this gas probably will form a part of the equipment of the alpinists of the future.

According to the researches of Dr. V. Schrotter, the relative lack of oxygen will be felt at a height of 4,000 meters and upwards, where the tension of the oxygen in the air is diminished to 12.5%. At a height of 7,000 meters to 10,000 meters, the tension of the oxygen falls to 6%. In regions exceeding 10,000 meters, the barometric pressure is 217 millimeters, and a sufficient oxygen tension in the lungs is no more attainable. Dr. Schrotter comes to the conclusion that life must cease at 9,000 meters, with a barometric pressure of 240 millimeters.

By the experiences of the Himalaya expedition, the researches of Dr. Schrotter have been fully verified. A member of the expedition, Dr. Kellas, got mountain-sick at a height of little more than 7,000 meters and died. By longer camping at heights of 7,600 meters, the constitution of four other members became accustomed or acclimated to the lack of oxygen, so that they could climb to 8,147 meters without using this gas. But only with the aid of oxygen apparatus did a part of the expedition succeed in climbing to 8,268 meters.

Other researches, recently made, have determined the amount of oxygen which must be inhaled at different heights in order to be able to climb without suffering. The quantities of oxygen, which must be added to the inhaled air, are for a height of 4,000 meters, 2 liters in each minute; for 5,000 meters, 3 liters; for 6,000 meters, 4 liters; for 7,000 meters, 5 liters and for 8,000 meters, 6 liters.

NEW LIQUID OXYGEN APPARATUS

A new apparatus for alpine purposes has now been constructed in Germany. This apparatus is charged with liquid oxygen, which constantly and slowly evaporates evolving quantities of gaseous oxygen. The apparatus consists of a steel cylinder, which can take up 1.3 liters of liquid oxygen. This oxygen gives 195 liters of gaseous oxygen at atmospheric tension, sufficient for 65 minutes at an altitude of 5,000 meters and for nearly 50 minutes in an altitude of 6,000 meters. The weight of the apparatus is so little that one climber can bear three cylinders, one of them for instance in his knapsack and the other two in a pocket fixed on a waist band.

The cylinder is connected with a reducing valve and a manometer, by which the pressure in the cylinder can be known. A special hand-wheel serves for regulating the outflow. The oxygen passes through the valve regularly, while the inhalation oxygen is taken in. During the exhalation the gas still escapes from the valve, but it would be wasted if not inhaled. In order to use this oxygen also, there is fixed on the cylinder a bag in which the gas is gathered in order to be inhaled at the next inhaling period. A small check-valve prevents the exhaled air from entering the bag.

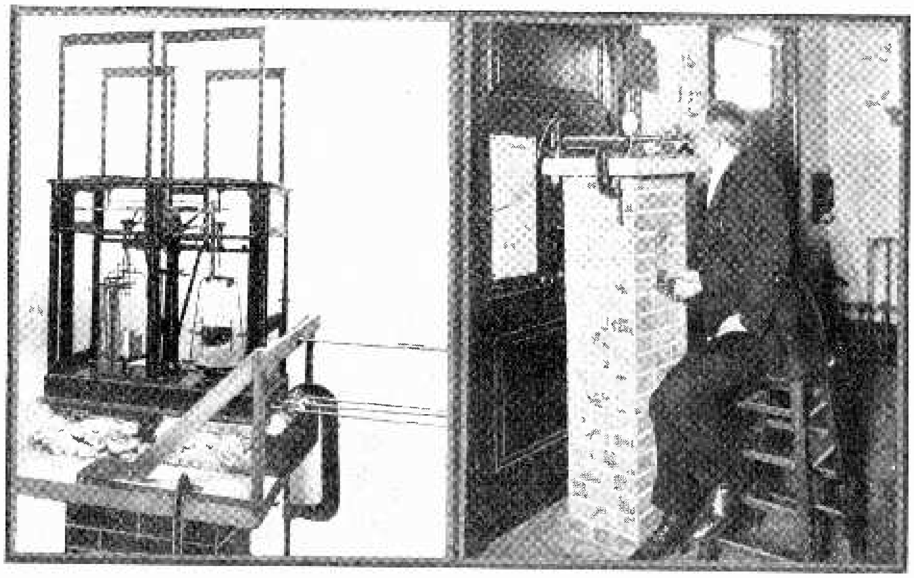
Weighing of Precious Stones Supports Einstein

By S. R. WINTERS

THE results obtained from weighing topaz and diamond crystals on a balance sensitive enough to detect a variation in weight of one part in a billion at the Bureau of Standards, tend to support the Einstein theory of relativity.

The Einstein theory of relativity, somewhat contrary to Newton's law of gravitation, disclaims that these crystals would vary in weight under any conditions. The conclusions of the scientific observations of Dr. Paul R. Heyl, a physicist of the Bureau of Standards, support the claims implied by the Einstein theory. The topaz and diamond crystals did not evidence any variation in weight irrespective of their different placements in relation to the axis of the earth.

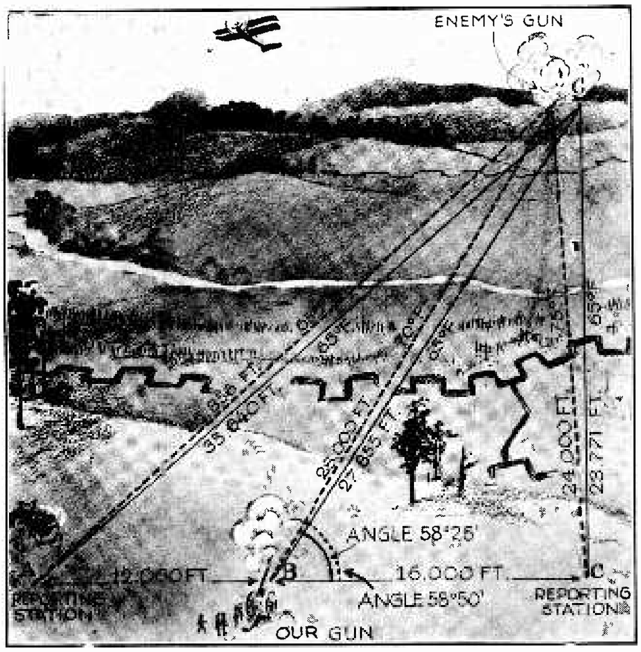
The balances on which these experiments were conducted are extremely sensitive—in fact, a variation of one part in a billion units would be faithfully reflected by them. This weighing apparatus is so delicate that it is enclosed in a small room, and weighing is done by remote control, thus obviating the influence that would be exerted on the balances from the heat radiating from the body of the operator. It was on these same balances that the signature of a President of the United States was weighed.



The Apparatus For the Weighing of Precious Stones As Used By Dr. Paul R. Heyl of the Bureau of Standards Is Shown At the Left and In Actual Operation At the Right. This Apparatus Tends To Support the Einstein Theory of Relativity.

No. 4. GUN-RANGING WITH SOUND AND RADIO

By HAROLD F. RICHARDS, Ph. D.



Left—The Importance of Taking Account of the Air Temperatures in "Sound Ranging" Guns is Shown in the Illustration Here Given. A, B and C Record the Time of Arrival of the Sound From the Hostile Gun G. C Receives the Sound 3.63 Seconds Before B, and 10.74 Seconds Before A. An Airplane Near the Line AG Reports the Temperature as 65° F. and the Calculator at B. Assuming the Temperature to Be the Same Throughout the Region, Locates the Enemy Gun at G, as Shown by the Full Lines. In Reality (see dotted lines) Due to the Different Temperatures Along Each of the Lines, This Aim Will Be 145 Feet Short and 203 Feet To the Right of the Enemy's Gun.

THE fact that sound travels at an excessively slow speed as compared with light and radio was turned to very good account during the recent war, and excellent work was done in locating German guns by timing the arrival of the sound of the explosion at three different reporting stations. In certain situations the low velocity of sound is a source of inconvenience, notably in auditoriums, where reflection from the walls frequently gives rise to an overlapping of the sounds uttered by an orator, who is speaking at the rate of two or three syllables per second; but in the war zone it was this very slowness of sound which facilitated the localization of dangerous guns at a distance of six miles or more, for if sound traveled as fast as light there would have been no practical means of detecting a difference in the times required for the sound of the explosion to reach the different reporting stations, no matter how far apart in the field they were situated.

The variation of the velocity of sound with the temperature of the air, however, frequently led to serious inaccuracies in the calculations, and consequently the Subaqueous Sound Ranging Section of the Coast Artillery Corps has recently undertaken an intensive study of the influence of temperature upon the speed with which sound is propagated. The first tests have been designed to furnish the required data for sound waves traveling in water, in order to effect improvements in localizing submarines and in the devices which automatically record the depth of the water through which a vessel is moving; but the method which Mr. E. B. Stephenson has devised for deep-sea measurements, in which he has so ingeniously put radio to a new use, is equally well adapted for determining the velocity of sound in air under different atmospheric conditions, and so we may shortly expect to be able to locate the sources of distant sounds with much greater accuracy than has hitherto been possible.

SOUND AND LIGHT VELOCITIES DIFFERENT

It is by no means a new discovery that sound travels with only moderate rapidity. Many persons of an inquiring turn of mind are accustomed to estimate the distance of a flash of lightning by counting the seconds elapsing between the flash and the thunder, and allowing five seconds to the mile, and it is a matter of everyday experience that a perceptible lag intervenes between the instants of seeing a pile-driver strike the pile and of hearing the sound of the impact, or between the instants at which a distant observer notices the emission of steam and sound in succession, from the whistle of a locomotive. A ballplayer in the outfield sees the bat collide with the ball before he hears the crack, and the soldiers in the trenches heard the shell whistling above their heads before they heard the sound of the explosion of the charge of the gun, which had sent the missile hurtling towards them.

SOUND VELOCITY VARIES WITH TEMPERATURE

The fact that the temperature of the medium affects the velocity of sound has long been known, and indeed the ratio of the two specific heats of a gas has frequently been determined by calculation based upon the law that the speed of sound in a gas is directly proportional to the square root of the absolute temperature. The rise of a great practical need, however, such as that of locating hostile guns with accuracy, has led to new and more refined methods of determining the influence of temperature and other conditions upon the speed of sound in various media. The most reliable results indicate that the speed of sound in air, at 65°, 70° and 75° Fahrenheit, is 1,125, 1,131 and 1,136 feet per second, respectively, and while the variation with temperature may at first thought seem too small to require attention, the reader has only to examine Figs. 1 and 2 in order to learn how important it is to take account of this variation when locating a distant source of sound. Station B notes the time at which the sound of the gun, G, arrives, and also receives electric signals indicating the instants at which the same explosion was heard at A and C. The distances of A and C from B are known, and the time-difference of the arrival of the sound at the three stations are recorded photographically, so that by using these known quantities in connection with a chart previously prepared with the aid of analytic geometry, the triangle can be constructed, showing the location of the gun, G. In Fig. 1, the calculator has assumed that a temperature of 65° F. exists throughout the region, whereas, in the case cited, the temperature is greater at the right of the field than at the left, as indicated in Fig. 2, so that the gun is actually 145 ft. farther from B, and 203 ft. farther to the left, than had been calculated neglecting the variation of the speed of sound with temperature. This error is sufficient to cause the gunner at B to miss the enemy's cannon at every shot; for at a distance of 5 or 6 miles, which is of the order we are considering, an expert gunner can place virtually every shot within a circle 100 ft. in diameter.

USING RADIO TO MEASURE SPEED OF SOUND IN SEA-WATER

The method by which radio is used to measure the speed of sound in sea-water is illustrated in Fig. 3. This device, which Mr. E. B. Stephenson has recently described in the *Physical Review* and in a pamphlet issued by the Engineer School, of Humphreys, Va., has already been tested by the Subaqueous Sound Ranging Section of the Coast Artillery Corps at Fort H. G. Wright,

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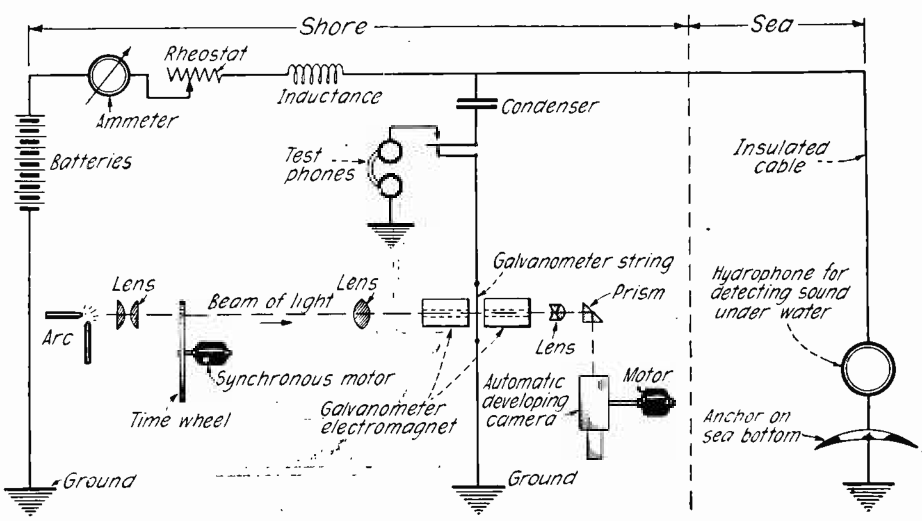

Apparatus Devised by Mr. E. B. Stephenson Which Will Be Used By the Subaqueous Sound Ranging Section of the U. S. Coast Artillery. At the Same Time That a Bomb is Detonated, a Radio Signal is Transmitted To the Apparatus On Shore, Which Time Is Recorded On a Moving Film. When the Sound Reachess the Hydrophone, Another Record Is Made.

Luminous Water Signs

A FRENCH inventor has recently devised a kind of animated advertisement which is quite novel, and which in interest and originality seems to surpass all the processes and systems hitherto employed for attracting the curiosity of passers-by.

It is based on an optical illusion, which has not yet been fully investigated, and which gives in an attractive fashion the impression of water in continuous movement. It comprises a moving transparent object brilliantly illuminated and the animated advertisement apparently in high relief. The transparency which can be placed directly upon the glass of the show window, or even in the interior of the store, consists of a subject painted on glass, or of an advertisement glued thereon, illuminated from the rear by means of a special installation, and in front by the general illumination of the store. Some parts of the presentation judiciously selected, are specially lit and given an apparent movement, thanks to an exceedingly simple arrangement which will be described below. Finally the whole can be accompanied by illuminated captions, which also can be animated.

The animated advertisement produced in relief is composed of natural objects, whose apparent movements agree exactly with their presumable nature.

It is extremely difficult to describe the impression of motion which such objects give, and it is quite necessary to have seen at least once a picture of this kind in action to really take in the effect produced.

We propose, following the lines of the inventor of this arrangement, M. L. Masson, described in *Sience et la Vie,* to try to explain this phenomenon by describing its causes. The movement, or rather appearance of movement, is obtained without any mechanism. It consists in circulating within glass tubes at a constant speed, what may be called a string of beads formed of drops of water which may be colored or not, with bubbles of air between them of about the same dimensions.

In the illustrations are shown examples of such animated advertisements in relief. The moving parts are contained within glass tubes, but when the system is in action the tube becomes indistinguishable because it is transparent, while the moving beads, as we have termed them, are what the eye sees. The eye follows the movement of the liquid pearls, and is attracted by this interesting and graceful spectacle, while the observer is puzzled in his attempts to account for the effect produced. The illusion is so complete that it would seem as if the tube is in constant motion. One has to touch it with his hand to realize that it is stationary. In the other system of transparency a different phenomenon appears, but one just as curious.

The apparatus is composed of a glass screen on which is glued or painted the image, leaving transparent the design which is to be animated. It is placed before a grating built up by a series of horizontal tubes spaced at regular intervals and parallel to each other, through which the water circulates, the beads in each tube moving in the opposite direction to that followed by those in the adjoining ones. At the back of the screen or at the sides, the illuminating system is installed.

The screen being in position, the beads do not show except at the transparent spaces, so that the succession of moving droplets attracts the eye and forces it to follow the movement, until as the beads disappear behind the opaque portion of the panel, others catch the eye; some being in the tube above or below, go in the opposite direction. An optical effect is produced which it is quite impossible either to imagine or to describe. The eye, attracted first by one and then by another of the stream of luminous beads going some to right and some to left, sees a design which seems to oscillate perpetually before it. For according to the thickness and layout of the transparent portions, the design which they form seems to undulate, twist, turn, dance, sparkle, and even flame up in a way altogether curious and picturesque for which no comparison can be found.

The effect obtained is pretty and varied, and is in the highest degree amusing.

The process employed for producing the beads consists in having water or any colored liquid, fall drop by drop, governed by a cock, into a tube of glass, of which one

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At the Left is Shown a Luminous Water Sign Used as an Advertisement of Medicated Iron. Cooled Water Pours From the Iron Press in Streams and Falls Into the Bottles, But the Latter Never Become Full.

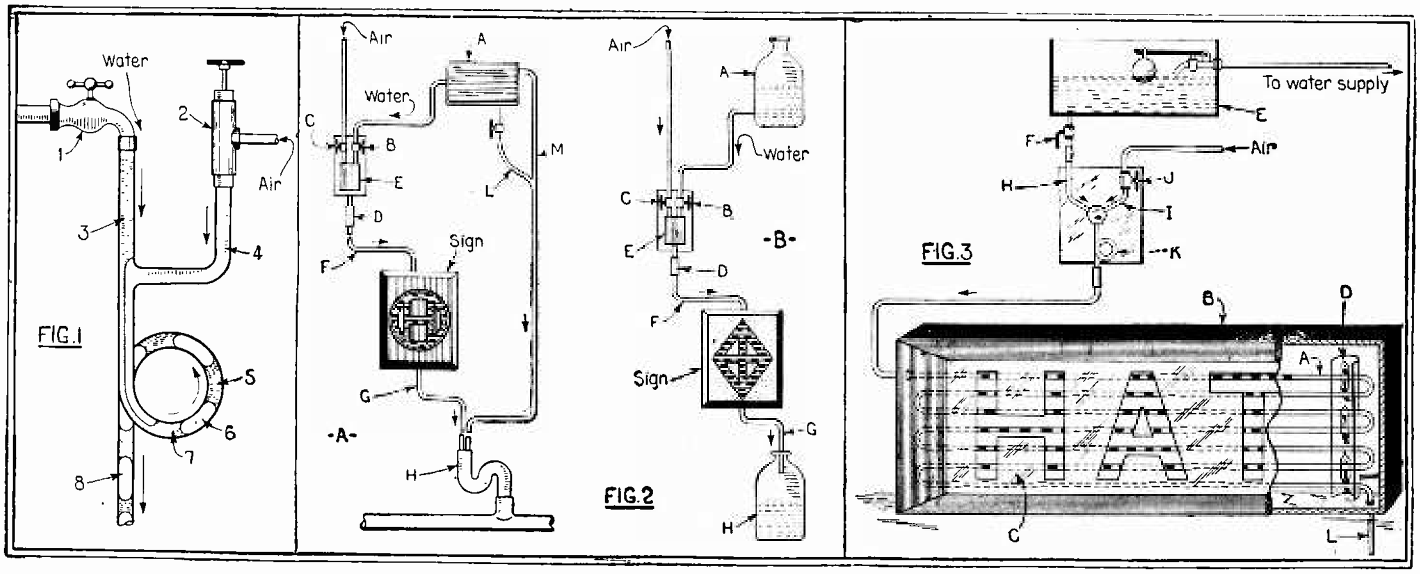
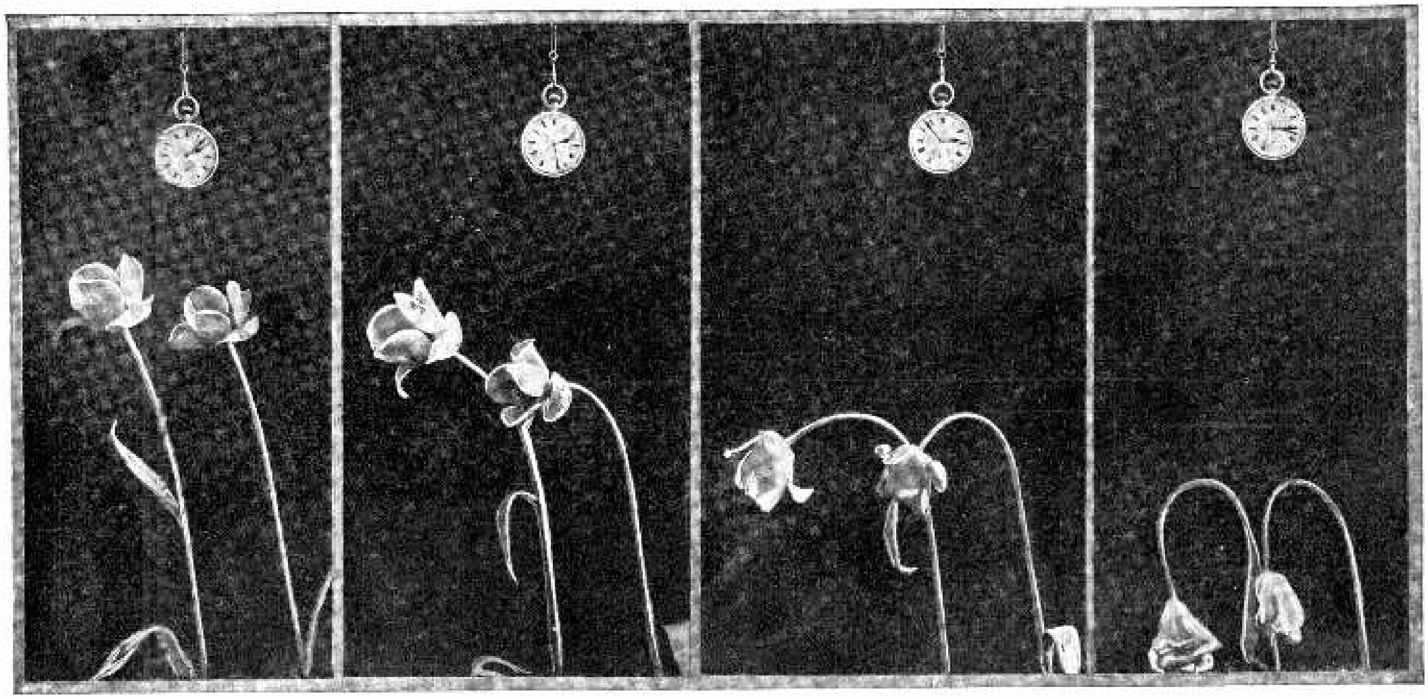


Fig. 1 Shows How the Water and Air Beads Are Formed. The Action is Obvious.

Fig. 2A Shows How a Luminous Water Sign Operates, But the Water is Wasted. Fig. 2B Shows a Similar Sign Where bottles or Other Reservoirs Are Used to Conserve the Water.

Fig. 3 Shows a Complete Illuminated Transparency Which Utilizes Parallel Glass Tubes Through which the bubbles of Air and Water Circulate. These Are Visible Through Letters Cut in the Front of the Cabinet Containing the Tubes.



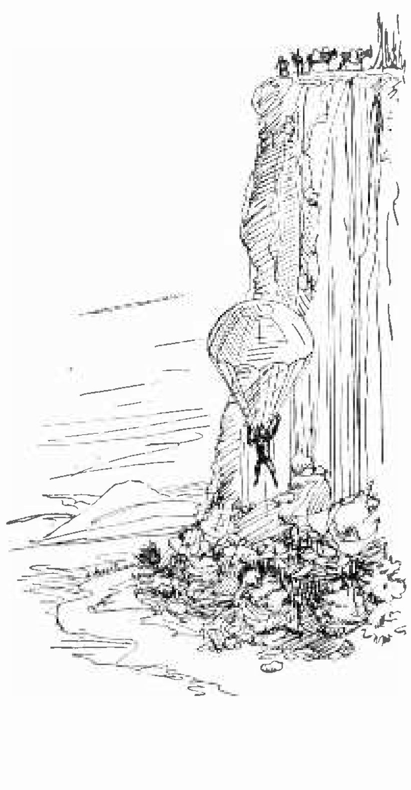
THE DEATH OF A FLOWER—The Tulips Were Mortally Injured at the Roots and the Time Which They Took to Die is Recorded by the Watch. Photos By S. Leonard Bastin.

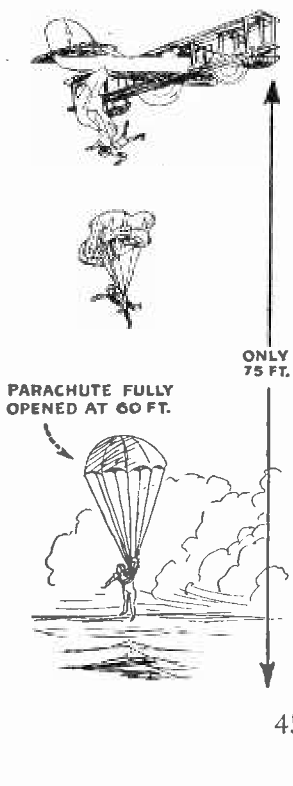
Parachute for Mountain Climbers

Quite frequently do we read of mountain climbers losing their lives by falling from a high precipice or being caught in a storm. Then again it has been stated that it is more difficult to descend a mountain than to climb it. All of this danger and difficulty can be eliminated if the alpinist will carry a seven-pound pack on his back containing one of the regulation U. S. Army parachutes. This parachute opens by merely pulling a cord, conveniently placed with a large ring on one end.

The new parachute is fully opened after a drop of sixty feet, and a man has actually jumped from the low altitude of seventy-five feet from a flying boat travelling at one hundred miles per hour. The breaking of a life line or a fall from a precipice need have no terrors now if one has a parachute. In case of a sudden storm or a perilous descent it will be safer and quicker to get down by means of the parachute.

Contributed by F. E. Loudy.





New Army Parachute Opens in 75-Foot Drop. Ideal Safety Device for Mountain Climbers.

Fire Under Water

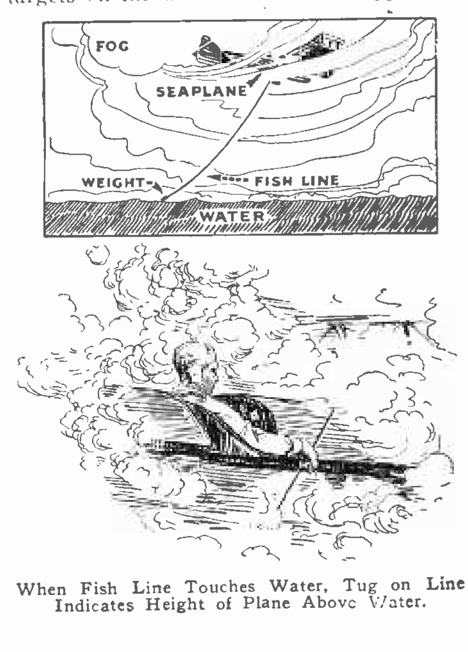
At first appearance this suggests a very fantastic idea, but it is the result of thirty years of technical experience of a Berlin firm. This firm has put this apparatus called "The Diving Condor" upon the market. When a heater for a bathtub fails or cannot be used for any reason, this apparatus helps out in an emergency, as it represents a subaqueous bath-oven for heating the water. Burning under the surface of the water, it prepares our bath and helps along with the house washing, replaces the fixed kitchen boiler installation, the big wash boiler, or the portable bath ovens, which are perpetually breaking down and needing repairs, etc. It is practical for use for any emergency requiring big tubs. The apparatus requires no expensive installation, is not expensive in the power it consumes and its installation is ten times cheaper than that of an ordinary gas stove.

Novel Heater for Bath Tub Water.

Fish Line Indicates 'Plane's Height

Mr. C. Francis Jenkins, the well-known motion picture machine inventor of Washington, whose system of movies by radio was described some months ago in Science and Invention, follows seaplaning as a hobby. He often goes seaplaning at night and he has invented a simple scheme of determining when he is but a short distance above the water, preparatory to making a landing in the dark. This scheme works in foggy or on clear nights equally well. He throws a twenty foot fish line over the side, at the lower end of which is a small sinker or weight, and then heads the seaplane slowly downward. As soon as he feels a tug on the line, he knows that it is touching the water and he then straightens out, preparatory to making a long slow descent toward the surface of the water.

Another novel and simple scheme for determining the height above land or water for aircraft, is that involving the use of two searchlights or small spotlights, the angles of one or both of them being variable by means of a calibrated dial control mechanism. Changes in altitude cause the light targets on the water to recede or approach.



When Fish Line Touches Water, Tug on Line Indicates Height of Plane Above Water.

Motor Car Leaps, Loops and Skids

By HAROLD F. RICHARDS, Ph. D.

OF THE GRADUATE COLLEGE, PRINCETON, NEW JERSEY

IMPROVEMENTS in aircraft and far-ranging projectiles have done a good deal to disabuse us of the idea that any body which apparently defies the laws of gravity is doing something paradoxical and unnatural, and yet one has only to converse with a number of his fellow motor-enthusiasts to find that there is the greatest diversity of opinion regarding the actual nature of the forces which are brought into play when an automobile rounds a corner or circles a banked track, or when the driver turns the front wheels in correcting for a rear-wheel skid.

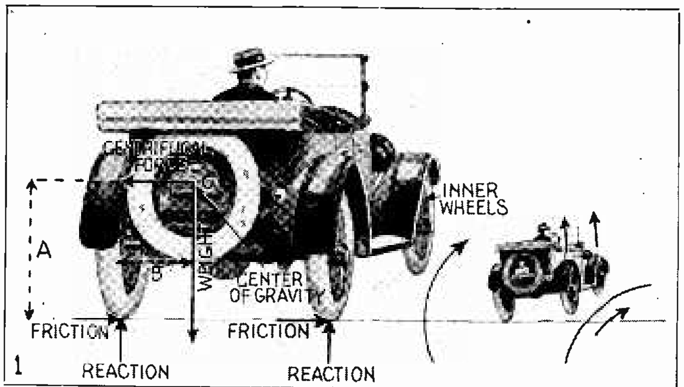


Fig. 1 Illustrates the Forces Which Tend To Lift the Inner Wheels When An Automobile Rounds a Curve at High Speed. This Diagram Shows the Forces Acting On the Machine If the Same Is Traveling On a Level Surface.

At this day and age it seems unnecessary to say that every one of the peculiar actions to which a speeding car is prone, is due to perfectly natural forces which are exactly as universal and inescapable as the force of gravity; and to the writer, at least, it has always proved more interesting to examine the natural causes of accidents and centrifugal effects than to try to become one of the walking "name-ometers" who can instantly give the make and serial number of a machine after one fleeting glance at the rear wheels disappearing around the corner.

Probably no delusion is so wide-spread as the one holding that the outer wheels are the ones which tend to rise when an auto rounds a curve. Even the promoters of racing bowls, who should have known better by observation, have sanctioned the posting of flaming lithographs showing a car racing around a curve with the outer wheels entirely off the ground. As a matter of fact, there is, barring collision, only one very rare case in which the outer wheels tend to rise from the road. The explanation of this effect, together with a number of other interesting phenomena, will appear at once after we have considered three very simple facts.

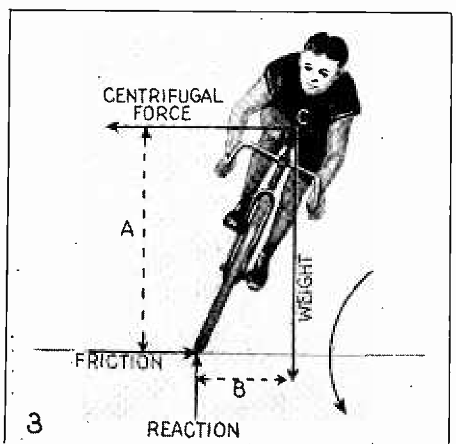


Fig. 3. A Bicyclist When Rounding a Turn Banks His Own Track By Leaning Inwards. If Weight Times Distance B Is Equal to Centrifugal Force Times Distance A, There Is No Tendency to Over-Turn.

The first principle to be noted is that the tendency of a rigid body to rotate or turn depends not only on the forces acting, and on their direction, but on where they act as well. Everybody is familiar with the fact that a gate turns most easily if it be pushed at the point farthest from the hinge. Experiment has shown that the rotational effect of an applied force is proportional to the force multiplied by the distance between the point of application of the force and the axis about which rotation is produced. This product of force times lever arm is called the *torque* of the force, and the torque bears the same relation to the rotation of a body as the force would to a straight-line motion of that body as a whole. The importance of this principle in automobile problems will shortly be made evident.

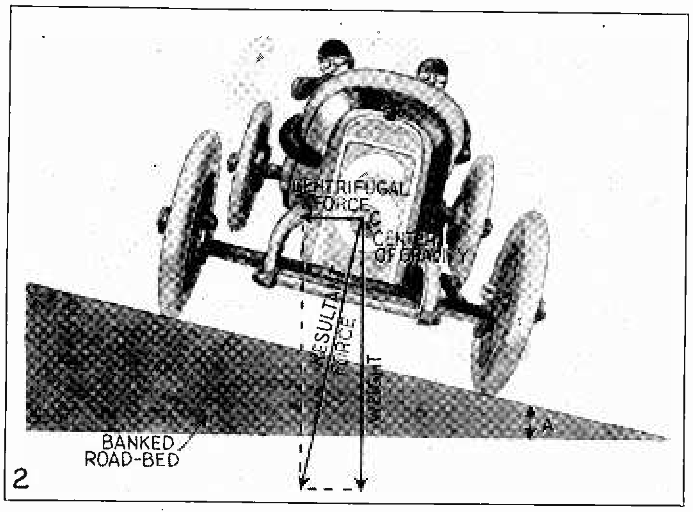


Fig. 2. If a Circular Speedway Is Banked At Such An Angle That the Resultant Centrifugal and Gravitational Forces Are Perpendicular to the Track, the Pressures On the Inner and Outer Wheels of the Car Are Equal, and the Car Does Not Skid.

The nature of the second principle to be applied will immediately become clear to anybody who will tie a bolt or nut to a string and whirl it around in the air. The string remains taut, showing that there is a force acting outwards along the string—that is, along the radius of the circle described by the rotating mass—and if the string in its whirling be allowed to pass through an intense flame, so as to be severed, the weight will be observed to fly off at a tangent to its circular path. The second fact shows that the body tended to continue in a straight-line motion, and the tautness of the string during the original whirling proved that this tendency of the body exhibited itself in the form of a force apparently pulling outwards from the center.

Centrifugal is merely the Latin for *fleeing from the center*, and centrifugal force is the outward reaction of a body moving along a curved path. Forces are always twins; they never occur singly; this centrifugal force may be considered to be merely the reaction to the force which holds the body in a curved path. Which of the forces comes first is as fruitless a question as the old one involving the hen and the egg.

One fact further, and we are ready to consider our flying automobile. Tie a rope to any point of the rear axle and lift the car bodily into the air. Draw an imaginary line down through the suspended car, in such a direction that it will seem to be an extension of the rope, that is, in the same straight line. Lower the car, and now fasten the rope to some other point of the car, preferably at the side, and lift the car again. Draw an imaginary line, as before, extending the direction of the rope through the car. Where these two lines cross, within the car lies the center of gravity of the car. This is an important point, for in all problems the weight of the car may be considered as acting as a single force placed at this center of gravity. This holds true even if the point should lie in empty space, say an inch or a foot above or below the floor of the car. If you do not believe it, run the car so that the front wheels are on one platform-scale, and the rear wheels on another; record the readings of the two scales, then replace the car by a light, stiff beam resting on two platforms, place a single heavy weight, equal to the weight of the car, at that point of the beam where the center of gravity of the car was previously located, and see whether after allowing for the weight of the beam, the indications of the two scales are not the same as before.

Now drive the car rapidly around a curve, on a level road. The forces acting are shown in Figure 1. The centrifugal force acts *outwards*, as drawn, and the torque due to this force—remember my previous paragraph—equals the centrifugal force multiplied by the distance A. This torque obviously tends to overturn the car outwards, and is resisted by an opposing torque which can be calculated by multiplying the weight of the car by the distance B. The outer wheels serve as fulcrum, or axis of rotation, being held in line by the friction at the road. If this friction is less than the centrifugal force, the car will skid outwards. Assuming a rough road, however, we can readily see that the inner wheels will or will not rise, according as the centrifugal torque is greater or less than the weight-torque. If the car does start to overturn outwards, B becomes smaller and A larger, hence, other factors being constant, the initial rise of the inner wheels increases the tendency to overturn. The lever arm of the force increases in length as the car turns over. This fact accounts for the suddenness of many accidents, such as turning turtle in a racing bowl.

The banking of race-tracks is designed to counteract the centrifugal torque. The centrifugal force and the weight may be combined into a single force (see Fig. 2), and the ange of the track should be so chosen that this resultant force will be perpendicular to the track. In this case, the forces on the inner and outer wheels are the same, and there is no tendency either to skid or to overturn. Since the centrifugal force depends on the speed, the angle can be exactly correct for a single speed only. Thus for a circular track, eight laps to the mile, the angle should be 66½ degrees for a speed of a mile a minute, and 84 degrees for 120 miles an hour (84 degrees is just 6 degrees short of the perpendicular). These values, of course, will vary slightly with the latitude and with the altitude above sea-level. In order to allow for varying speeds, the track is usually constructed with an upward curve rather than a straight inclination, so that the driver can mount higher on the track as his speed increases, and thus pick out the correct angle. No matter how great the speed, however, the car can never hold to a perpendicular wall, when running around it; for in this case both the momentum and the centrifugal force act at right angles to the weight, the one forward and the other outwards, and no force can ever be counterbalanced by one acting at right angles to itself.

The bicyclist secures the effect of banking by leaning inwards when rounding a corner, as shown in Fig. 3. The same reasoning regarding torques applies here, as above. The difference, of course, is that the ground reaction is not in line with the wheel, if the friction is too small, and consequently there is danger of skidding and falling. The common error of considering that an automobile inclines inward when rounding a curve is doubtless due to the drawing of an incorrect analogy from the inward lean of a cyclist. There is just one case in which a car can tend to overturn inwards, and this is where the car, already high up on the side of a banked track, starts to slide sidewise down the slope, owing to incorrect angle and insufficient friction. Then, the car, having acquired lateral momentum in sliding down the slope, a rough spot on the track may catch the inner wheels and cause the car to overturn inwards, due to this momentum.

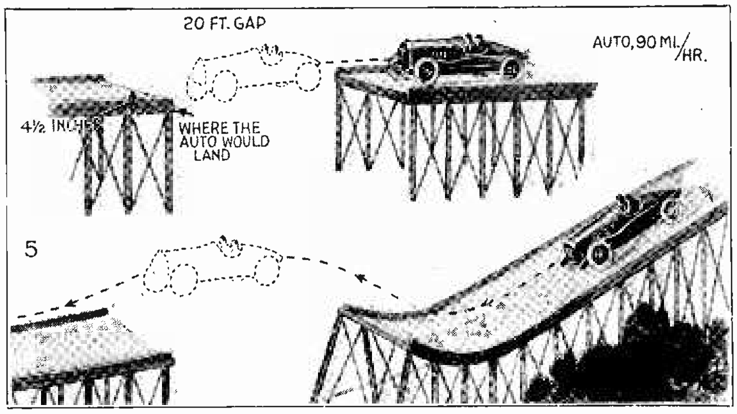


Fig. 5. In Leaping a Twenty Foot Gap, An Auto Traveling Ninety Miles An Hour, Drops 4½". The Upward Curve of a Starting Runway Counteracts the Gravitational Drop and Also Causes Auto To Land On Four Wheels.

The centrifugal force is also the important factor in looping the loop, as shown in Fig. 4. In position 1, the momentum of the car supports it against gravity, and the centrifugal force holds it to the track. In position 2, the momentum is at right angles to the force of gravity, but the centrifugal force supports the weight of the car; and in position 3 gravity is augmenting the momentum and, as before, the centrifugal force pulls the car against the track. The driver is at all times subjected to the same centrifugal force, and to the same momentum, as the car, and so he feels no tendency to fall from the car when it is inverted at the top. His pressure upon the seat, however, will vary and if at the top the centrifugal force is just equal to the weight, he will exert no pressure whatever upon the seat. The fact that in this position the greater weight, that of the car, is above him, does not enter into the result; since in case of accident both driver and car would fall with exactly the same speed.

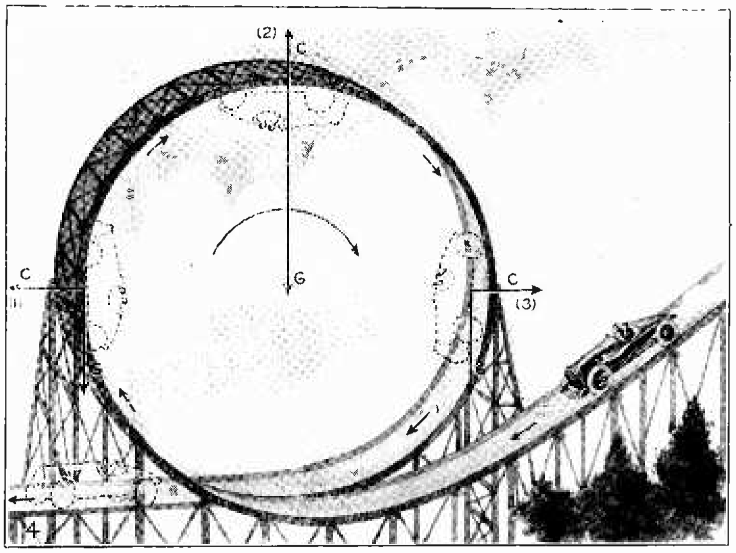


Fig. 4. Looping the Loop. C Represents Centrifugal Force, and G Gravitational Force. C Must Always Be Greater Than G at the Top of the Loop. The Driver Being Subjected to the Same Force As the Car, Feels No Tendency To Leave His Seat.

In leaping the gap, a favorite trick of Barnum and Bailey some ten years ago, the momentum, rather than the centrifugal force, is the important quantity. In considering the mechanics of this feat the reader must remember that a body projected horizontally in free space drops in one second exactly the same distance as a body falling from rest. Thus, for the speed and the gap shown in Fig. 5, the automobile could not possibly leap from one level plane onto the other. The momentum of the car would carry it across the gap, but during transit the car would fall 4½ inches, and even if the front wheels were able to climb upon the landing plane, owing to their curvature, they would in so doing throw the rear wheels still farther down, and the result would be tragic headlines in the newspapers. To allow for the gravitational drop, the projecting plane is curved upwards, and the same upward curve gives another advantage; namely, the rear wheels, which apply the power to the track, are the last to leave, and consequently the car is given a forward tilt which causes it to land flat-footed on the opposite platform.

To pass from rare feats to an every-day experience of motorists, why is it a good plan to turn the front wheels in the same direction in which the rear wheels are skidding? The fact remains that rear skids are often checked by turning the front wheels toward the skid. Figure 6 shows the forces involved. The skid is to the right, and consequently the car tends to twist in the direction shown by the first curved arrow; on turning the front wheels sharply to the right, however, the frictional force F is called into play, owing to the fact that the forward momentum of the car momentarily causes it to tend to continue moving forward, and this force F has one component, namely B which is perpendicular to the wheel. This force B combines with the frictional forces opposing the rear skid to produce a torque in the opposite direction to the original turn of the car. If the front wheels also skid, the story is much sadder, as the motorist knows.

The results of a blow-out, to which so many fatal accidents are attributed, are.

(*Continued on page* 483)

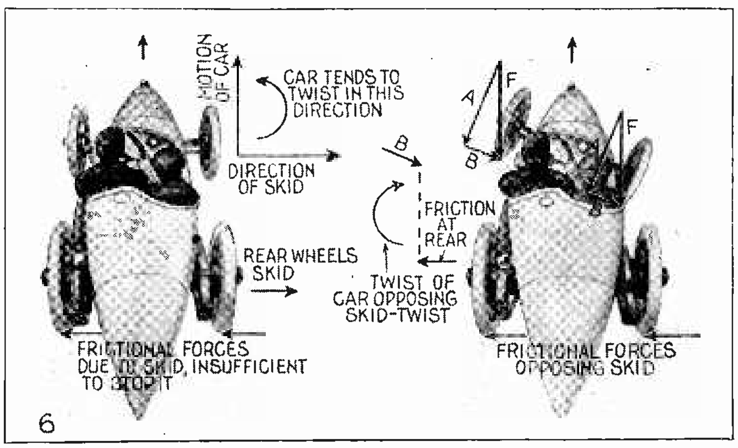


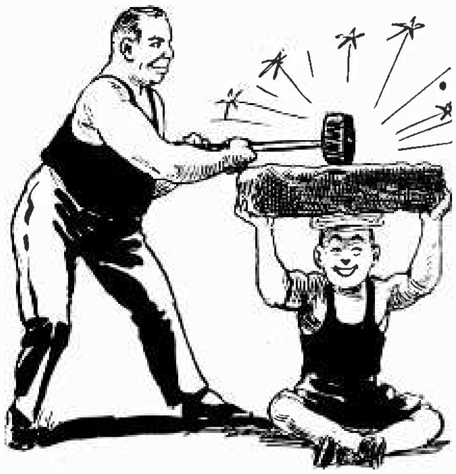
Fig. 6. By Turning Wheel Sharply In the Direction of the Skid, the Driver Calls Into Play the Frictional Forces F, Due to Forward Momentum of the Car. A and B Are Two Components of F. B Together With Frictional Forces at Rear of Car, Tends to Twist the Car in Direction Opposing the Skid.

Scientific Problems and Puzzles

By ERNEST K. CHAPIN

No. 10 OF A SERIES

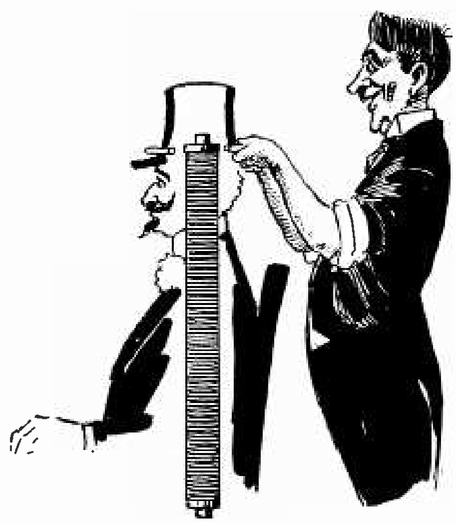
A STAGE magician once excited great astonishment by his feats of superhuman strength. In one of the most spectacular of his performances he would support a huge rock on his head and invite the strongest man in the audience to come up and crack it with a sledge hammer. If the efforts of the man were at first fruitless he would urge him to strike harder until at last the stone broke under the blows. Although the man went through this performance as many as seventeen times a day, there was nothing interposed between the stone and the man's head but a small blanket. Do you see how this feat can be possible without resort to trickery of some kind?



Would You Smile Under This Kind of Treatment? The Young Man Who Is Seated Seems to Be Enjoying It Immensely.

THE ENCHANTED RING

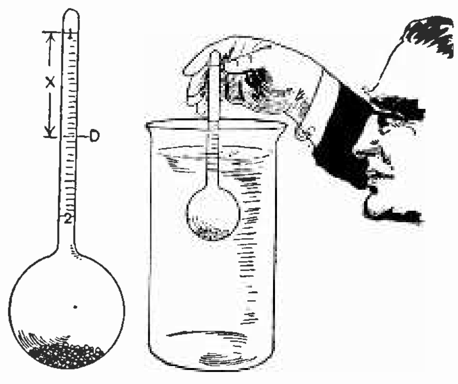
A trick which to the unsophisticated borders on the miraculous may be presented as follows: The magician invites someone up in front where he exhibits a figure dressed up to represent a small man wearing a silk hat. After some preliminary lingo about the shady history of the individual the representative from the audience is asked to place a ring or loop made from a few turns of heavy copper wire over the man's hat and observe a demonstration of the man's satanic powers. Much to his consternation he finds that the ring resists quite strongly his efforts in this direction as if acted on by an invisible or occult force. Furthermore, it gets quite hot in his hands as if the fires of Inferno had been invoked. Can you explain how these surprising results can be obtained by invoking only the known laws of science?



If You Were Unable to Place a Ring Over a Man's Hat and the Ring Got Hot in Your Hands, What Would You Think Was the Matter?

CALIBRATING A HYDROMETER

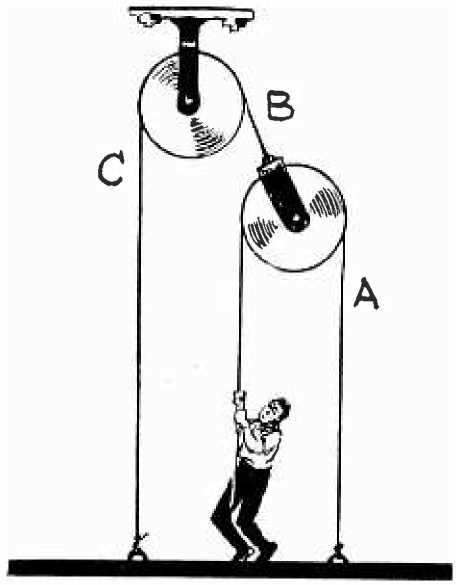
A boy is making his own battery hydrometer. He has blown a bulb on the end of a piece of glass tubing, loaded it with shot so that it will float vertically in water, and sealed off the top so that the shot cannot spill out. He now floats it in water and marks the level on the stem, lettering it "1" to indicate that at this point the hydrometer registers a density of 1 gram per cubic centimeter. But now comes a serious difficulty, for he doesn't know how to calibrate the rest of the stem without making up a lot of solutions of known density and floating the hydrometer in each one in succession. It would simplify matters immensely if someone would show him a way to figure out how far below the first mark he must place any other mark that is to indicate some particular density. The weight of the hydrometer is 20 grams and the cross sectional area of the stem is 0.25 sq. cm.



Knowing How Far a Hydrometer Sinks in Water, How Would You Calibrate It for Other Liquids?

ANOTHER PULLEY SYSTEM

In the accompanying diagram of a pulley system how hard must the man pull to maintain himself in equilibrium if his weight is 160 lbs. and that of the plank on which he stands is 80 lbs.?



The Man in Our Illustration Seems to be Having a Hard Time Trying to Keep Himself from Falling. How Much Force Must He Exert in Order to Do So?

WAXING OR WANING?

Ask the average mortal how he can tell at a glance whether the moon is waxing or waning and he will look at you as if you had asked him something about the Einstein theory or the fourth dimension. But ask old Granny Hilton, who believes that all human ups and downs follow the changes of the moon with unfailing regularity, and she will tell you as soon as she can get a peep at it. Can you figure out how she does it?

(*Continued on page* 503)

Can You Tell Whether the Moon at Which Our Young Couple is Gazing is Waxing or Waning?

Ozone Made To Order

Ozone, the intangible substance that makes the air fresh and pleasant after a thunderstorm, and that gives the sea-breeze its invigorating quality, is now being electrically produced to aid in solving problems of ventilation and air supply in schools and work places where people are crowded together. Two schools, each housing one thousand pupils, were used throughout the past Winter, and it was found that the school in which the air was impregnated with ozone had less illness among its pupils, that it had only one-third as many absences for illness, and that the absences were shorter.

Ozone, produced electrically by a generator installed in the air-duct of the building, is added to the air at the rate of one part of ozone to two million parts of air.

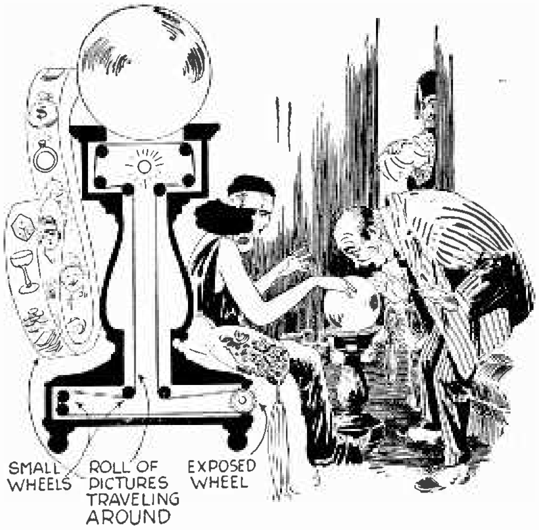
Magic For Everybody

By PROFESSOR JOSEPH DUNNINGER

NO. 6 OF A SERIES

Left—The Magician Opens a Box On the Table Which Is Brimful of Candy. Taking Out Several Pieces He Proceeds to Devour Them. Some Guests Remark On His Seeming Bad Manners In Not Offering the Candy to Others. They Are Told to Help Themselves, But When They Open the Box They Find It Completely Empty.

Right—Usually In the Art of Crystal Gazing Only the "Medium" Sees Visions, But With This New Type of Crystal All the Spectators May Distinctly See the Apparition. Pictures On An Endless Film Rotated By a Small Wheel Actuated By the Foot, Are Magnified By the Crystal Ball.



CRYSTAL GAZING

YEA, in the days of ancient Egypt, when enchantment and so-called witchcraft was in vogue, the ancient crystal was used by the wizards of old as a mystic mirror in which could be seen the reflection of the things to be. Much of Biblical importance and religious value has been attached in the centuries gone by, to the predictions which have been made by soothsayers after consulting the so-called mystic spheres of mysterious information. With the twentieth century and its many explanations of the many things at one time seemingly impossible, with achievements such as the radio, the submarine, the telephone, etc., has come a disbelief in the probabilities of forecasting through the focus of the mystic sphere, and yet there are many that claim that they can actually see things in the crystal.

Public wonder workers are to some extent using the crystal as an object of a most delightful form of entertainment, many of the society people whom I have entertained, have positive belief in the crystal as an information bureau. As per the title of my articles "Magic for Everybody," it is merely my intention to offer in this series tricks of a nature, such, as to prove of practical demonstrative value to my readers, and I will therefore not attempt to criticize the believers in the weird art of *crystal gazing*, nor will I attempt to deprive or destroy the religious value that some have attached thereto.

I offer herewith an original method of crystal gazing which will be found to be of unique value to those caring to put themselves to the trouble of constructing the paraphernalia necessary. It has its advantages over the average so-called form of crystal gazing, inasmuch as the operator or wizard wonder, as you care to term him, has absolute control over the sphere, and therefore can cause his friends to actually see things in the enchanted globe.

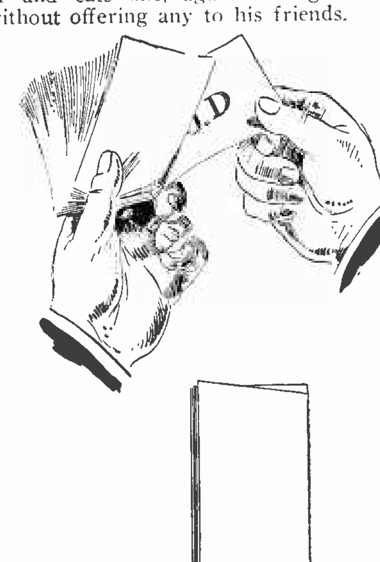
HOW THE CRYSTAL GLOBE IS BUILT

Referring to my diagram one will find that the stand upon which the crystal rests is the responsible item for bringing about the necessary results. Passing over a series of small wheels will be found a roll of spirit pictures. These pictures, which are rather small, should be painted upon a roll of black canvas cloth with phosphorous paint, the purpose of which will be readily explained. A small wheel with pointed edge is exposed, in the base of the stand, and also is a member of the series upon which the roll of pictures travel. It will not be necessary to explain that by turning the wheel, the pictures which are traveling upon an endless loop will be brought to view beneath the upper opening of the stand one at a time. The crystal ball being of solid glass (it may be an inverted fish aquarium) has magnifying qualities, and the subject looking into the crystal will therefore see the picture beneath, magnified many times, and as the basis of the cloth upon which the pictures are painted is a dull or dead black, the picture will to all appearances present itself apparently within the center of the sphere.

MAGIC CANDY

Smilingly the magician walks over to a table upon which is resting a candy box, and apparently carelessly opens the cover thereof and eats one, again closing the cover without offering any to his friends.

One of the spectators is sure to comment thereupon, and the magician with surprising apology for his seeming neglect at once makes his way to the table and offers the box and its entire contents to his friends to partake of the candy. Much to their surprise, however, when the cover is lifted, the box which a moment ago was brimful with the choicest of sugared goodies, is now entirely empty. The candies really consist of but one layer, which are contained in a tray, held to the upper edge of the box by a set of catches, which will not release until the cover of the box is shut down tightly. In this cover will be found a loose working flap the top side of which has been covered with material similar to the table top covering. When the cover of the box is closed down tight the catches holding this tray are released and the tray of candies travels down through the box, which is bottomless, and rests itself in a trap made to receive it in the table top. The flap also travels through the box and covers the candy and tray, so that when the box is removed from the table no traces of the sweets can be found. A set of flaps working on small spring hinges are held in place to the sides of the box, as shown in the drawings, and then when released at the proper time, fall into place, forming a false bottom.



It Is Not Generally Known That Cigarette Papers Are Cut On the Bias, and That If One Of Them Is Initialed and Placed Into the Pack, the Performer Can Find it With Ease, Even Though Blindfolded and Holding the Package of Papers in Back of Him.

THE CIGARETTE PAPER TRICK

The Effect: A package of cigarette paper of the average kind and quality is passed about for thorough inspection.

One of the cigarette papers is taken from a package and is secretly marked while the performer has left the room. It is then mixed in with the rest so that it's direct location is unknown. The performer places the papers beneath a table, or behind his back, so that his audience is convinced that he cannot possibly see them and immediately draws out the marked one. How is it done?

Inspection will prove that most cigarette papers are cut on the bias, that is to say, instead of the corners being square, they are cut at an angle. While one paper is being marked the performer leaves the room. When the marking has been done, he is recalled and brings with him the balance of the sheets. The performer secretly sees that when the marked paper, which is turned mark side down, so that he cannot see it, is returned to the stack, the package is so turned that when the paper is replaced two of its corners will protrude slightly. The magician has but to feel for the projecting corners and draw out the marked slip.

Experimental Electro-Chemistry

By RAYMOND B. WAILES

PREPARATION OF SODIUM OR POTASSIUM METAL AND AZOBENZENE; ELECTRO-CHEMICAL WATER PURIFIERS AND HOME BREW "AGERS"; ELECTROLYSIS OF GLASS

GLASS, we have been told and found by experiment, is a non-conductor of electricity. Perhaps the last item of the title of this paper, as given above, would seem misleading. However, the statement relative to the electrical conductivity of glass should be modified with a phrase . . . at normal temperatures. That is, at room temperature glass will not conduct an electric current. But if a bit of glass be heated to redness it will conduct electricity. This can be proved by impinging a Bunsen or other blue flame upon a piece of broken glass until the glass is intense red and soft. Now, by applying to the plastic glass two wires which are connected to a strong battery or other source of current with a suitable indicating instrument in series, the index of the instrument will be deflected, the current flowing through the molten or plastic glass.

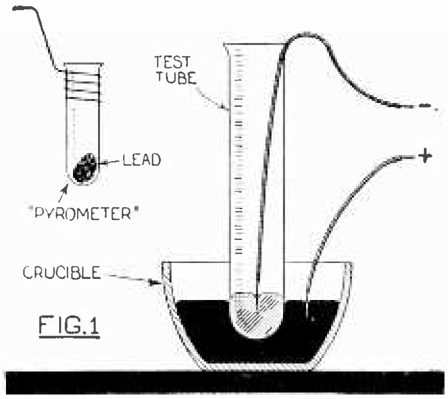


Fig. 1. Glass, Commonly Called a Non-Conductor of Electricity, Can Be Electrolyzed With This Extremely Simple Cell. The Little Pyrometer Shown in Detail is Used to Judge the Temperature of the Metallic Electrolyte in the Crucible.

Using a fairly high current strength and 110 volts potential, glass can be electrolyzed at a temperature of about 300° Centigrade (572° F.). This temperature is not sufficient to make glass plastic or even red hot.

Just how this can be done is disclosed in Fig. 1. Here a test tube containing mercury is inserted into a porcelain crucible containing sodium amalgam. Sodium amalgam as we have already seen, is an alloy of sodium and mercury, alloys of mercury being termed *amalgams*. This amalgam can be made by dissolving clean and dry sodium metal in mercury. A 3 per cent sodium amalgam (3 by weight of sodium to 97 by weight of mercury) is adapted for this experiment. An iron wire should be inserted into the crucible and another iron wire into the test tube, one making contact with the mercury and the other with the amalgam. These are the electrodes, the crucible being made the anode and the test tube the cathode. The crucible should now be heated to a temperature approximating 300° C. and a heavy current, preferably from a 110-volt circuit D. C., of course, at about 5-10 amperes for several hours. At the end of this time, the mercury in the test tube should be treated with several drops of water and a strip of red litmus paper touched to the liquid. The paper will turn blue, showing that sodium has been actually "plated" out on the mercury in the test tube.

The addition of water forms sodium hydroxide with the small amount of sodium in the sodium amalgam which forms by the electrolysis, and this sodium hydroxide (NaOH) affects the red litmus paper. So, if the red paper turns blue, we can say that electrolysis of the glass has taken place.

A simple pyrometer which can be employed to secure the proper temperature for electrolysis can be made from a glass tube, sealed at one end and containing pieces of lead (not solder). When this little pyrometer is immersed slowly to prevent cracking by means of a wire into the sodium amalgam in the crucible, the lead will melt if the temperature is above 320 degrees, which is sufficient for the electrolysis.

MAKING METALLIC SODIUM OR POTASSIUM

An iron crucible containing molten sodium hydroxide or potassium hydroxide sticks heated by a Bunsen burner can be used as the electrolyte. The cathode is an iron wire terminating in a spiral and inserted into the bottom of a porous ignition crucible, made of alundum or other refractory material. This crucible is inverted and dips into the fused electrolyte and protects the metallic sodium or potassium from combining as fast as it is formed with the oxygen in the air. About 15 amperes should be used for the electrolysis and as fast as the inverted crucible yields the metal, the rod and crucible hanging to it should be removed from the molten caustic bath and given a sudden jerk under kerosene. The sodium or potassium metal will then fall off and be preserved by the kerosene.

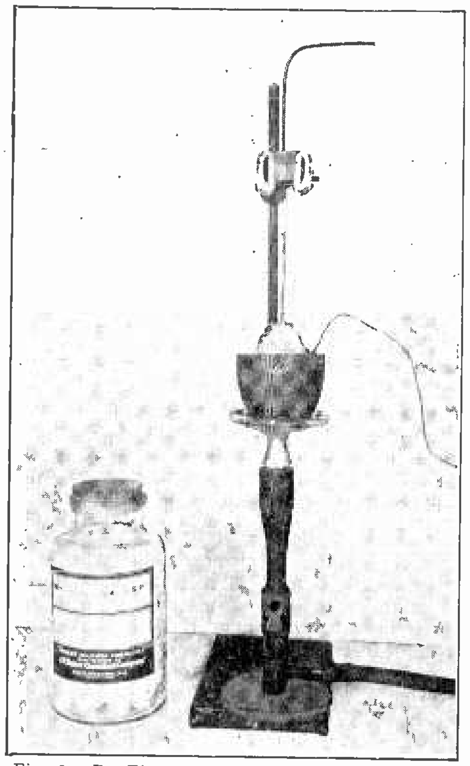


Fig. 2. By Electrolyzing Fused Sodium Hydroxide, Metallic Sodium Will Collect in the Inverted Crucible Shown Here. This Prevents the Sodium from Spontaneously Reacting With the Air.

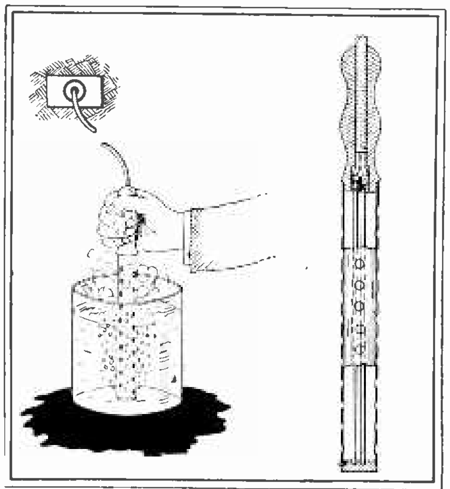


Fig. 4. This Instrument Purifies or Clarifies Liquids. It Operates on the Principle that a Gelatinous Insoluble Precipitate of Aluminum Hydroxide Forms on the Aluminum Electrodes, When Connected to the 110 Volt Circuit and Immersed in a Liquid; This Precipitate Carries Impurities to the Bottom of the Container.

The heating should be carried out, keeping the caustic alkali in fusion for about an hour before the electrolysis is begun. It must be remembered that the sodium or potassium which is produced reacts with water, forming hydrogen gas and the corresponding hydroxide, this being the reason why an aqueous solution of a potassium or sodium salt such as the hydroxide could not be used. The bowl of a clay tobacco pipe can be substituted for the crucible if desired. It should be inverted and the mouth dipped into the molten or fused electrolyte so that air cannot enter and spoil the reaction product. If sodium hydroxide is used, sodium will form, and if potassium hydroxide is employed as the electrolyte, potassium will be the product. Fig. 2 shows the apparatus as set up.

AZOBENZENE FROM NITROBENZENE

Important to the dye industry is azobenzene. This substance crystallizing in beautiful red rhombic crystals can be made by the electrolysis of nitrobenzene. This latter substance is made by the action of nitric and strong sulphuric acid on benzene which can be obtained from coal tar distillates.

Nitrobenzene has the formula $C_6H_5NO_2$. While Azobenzene has the formula $C_6H_5N = NC_6H_5$. It can readily be seen that the latter substance is devoid of oxygen atoms. It is by an electrolytic *reduction* that the two oxygen atoms of nitrobenzene are to be removed, producing the azobenzene. During the electrolysis hydrogen gas is produced, and this being in the *nascent* or newly born state combines with this undesired oxygen and forms water.

Fig. 3. Azobenzene, Important in the Dye Industry, Can Be Made in the Form of Red Crystals, Using This Electrolytic Cell Containing a Semi-permeable Diaphragm.

For the electrolysis a beaker or battery jar containing the following solution should be used: 20 grams nitrobenzene (oil of mirbane), 5 grams of sodium acetate and 200 cc. to 75 per cent alcohol. Pure grain or ethyl alcohol should be used, although some

(*Continued on page 482*)

Practical Chemical Experiments

By RAYMOND B. WAILES

INTERESTING FACTS ABOUT SULPHUR

WE all have in the past few months, come into contact with more sulphur than at any other time of the year. This goes for those who have taken their annual dosage of sulphur and molasses and those who have had their year's sport in the Fourth of July celebrations with fireworks, which contain sulphur in several forms.

But besides being the basis of spring tonics, fireworks, matches, and other everyday commodities, sulphur has found use in many products. The wealth of a nation, it has been said, could be computed by reckoning the amount of sulphuric acid it produces and annually utilizes. A step farther than this can be taken. The wealth of a nation could be computed on the amount of sulphur it uses, for it is with sulphur or a form of sulphur with which sulphuric acid is made, the world's most important chemical.

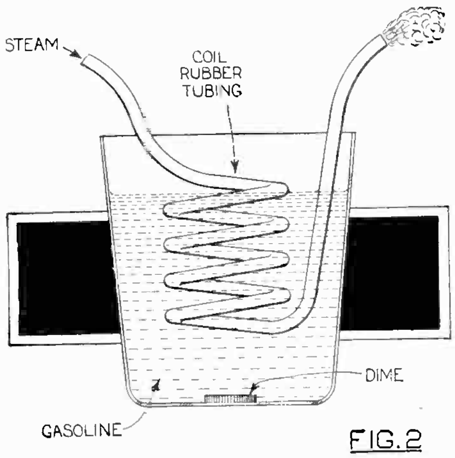
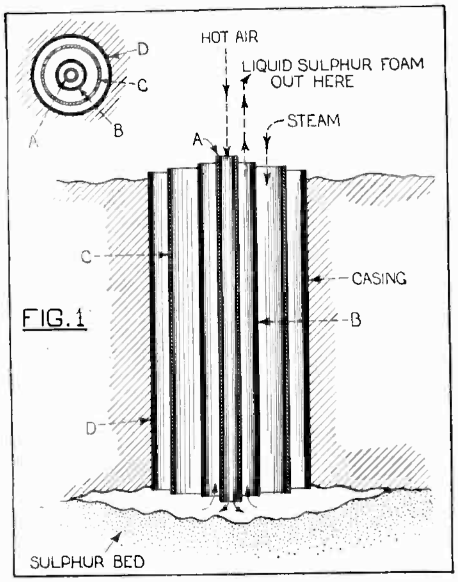


FIG. 2

By Using the Above Arrangement, You May Determine Whether or Not the Gasoline You Use Contains Sulphur; a Silver Coin Turns Black If Sulphur Is Present.

Sulphur is an interesting substance the moment it is mined. This can at once be confirmed when it becomes known that sulphur is first melted in the earth and then pumped from it. This novel method of robbing mother earth of its treasure was developed by Herman Frasch in 1871. Figure 1 shows the method now in use.



Diagramatical View of the Apparatus for Obtaining Sulphur From the Earth. The Action Is Fully Described in the Text.

Here, four concentric pipes, 1, 3, 6 and 8 inches respectively in diameter are introduced into the drilled well in the sulphur-bearing region. Hot air is forced down the smallest and inside pipe, and super-heated water is forced down the six inch pipe. This superheated water soon causes the sulphur to melt, and by the aid of the hot air forced in through the inner or 1 inch pipe, the sulphur is forced from the bed through the three inch pipe, along its length, and out at the top. Virtually, a foam of sulphur, steam and air is produced, the whole mixture passing out at the top of the pipe marked E. The larger or 8 inch pipe serves as a protective casing for the three innermost pipes, the air space between C and D (6 and 8 inch) tending to maintain the heat within the pipe C and not allow it to escape into the surrounding earth and thus cool the superheated water which is continually being pumped into the sulphur well.

The retort, Fig. 3, contains crystallized sulphur (flowers of sulphur will serve). By heating the bottom of the retort slowly with the Bunsen burner the sulphur will at first melt and then pass over into the neck. Several passages of the burner at the neck will serve to keep it melted at this point and so that it will not clog the tube. Drops of sulphur will now fall into the cold water in the beaker, and later a stringy rubber-like mass will exude.

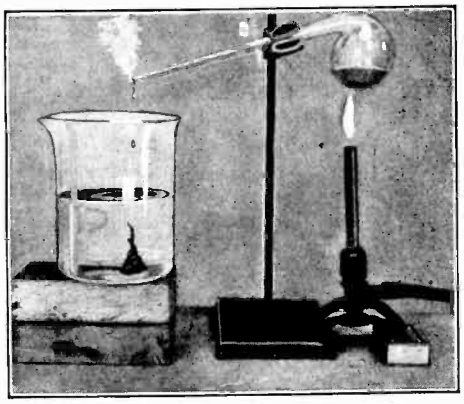
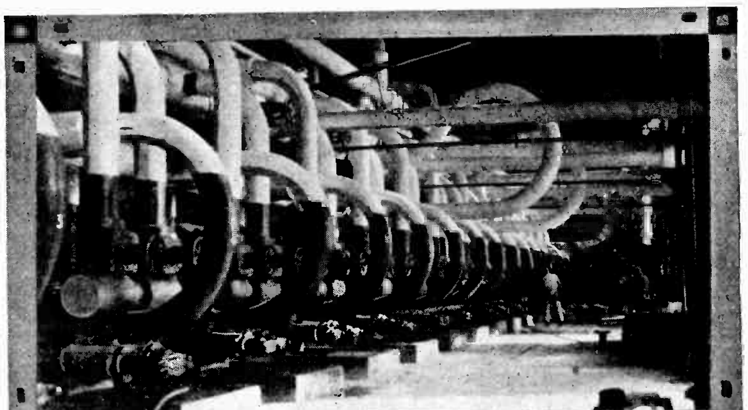
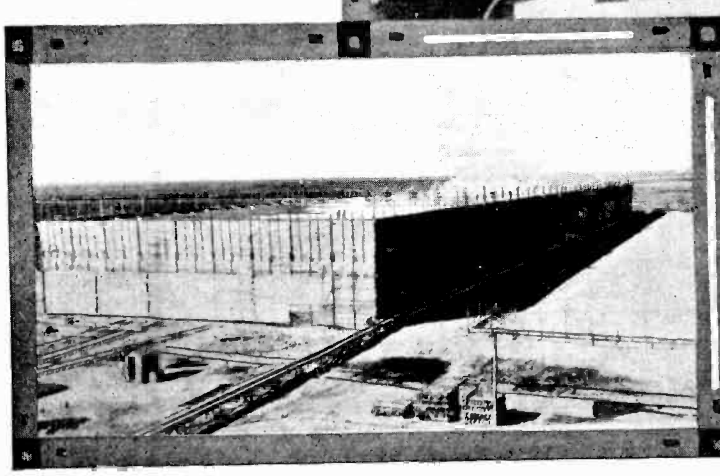


Fig. 3. Making Plastic Sulphur Which Can Be Moulded and Worked Into Various Shapes in Much the Same Manner as Clay.



At Left: High Pressure Pumps Which Force Super-Heated Water Into the Well to Melt the Sulphur, So That It May Be Extracted.



Lower Left: One Hundred Thousand Tons of Sulphur Cooling in a Bin After Extraction From the Earth.

Below: Blasting the Sulphur From the Huge Block After Cooling and Loading It on Cars.

Selenium Star Photometer

By LEWIS J. BOSS

THIS little device, the latest aid which science has brought to the astronomer to assist him in delving into the depths of the universe, is in itself essentially simple. Briefly, it consists of a sensitive selenium cell connected in the same circuit with a very delicate galvanometer, a variable high resistance and a source of electric energy such as an ordinary battery.

The light-sensitive cell is affixed to the eyepiece of the telescope and takes the place of the observer's eye. It is in fact an electrical eye, which is many times more sensitive to variations in light than is the human eye. Selenium, a non-metallic element occupying the intermediate space between sulphur and tellurium, was discovered in 1817 by Berzelius while he was experimenting with the Fahlun pyrites in an endeavor to manufacture sulphuric acid from them. It enters into the manufacture of some kinds of ruby glass, and is obtained in several different forms, namely, amorphous, vitreous, colloidal and "metallic" selenium. The "metallic" form is produced from the vitreous variety generally and is the only modification of the element which is light-sensitive. This substance is found to possess the ability to conduct electricity with greater or less facility accordingly as greater or less amounts of light are allowed to shine on its surface.

Since this is so, it follows that if we allow rays from a variable source of light to fall on an instrument containing such a sensitive cell and connect it to suitable indicating and controlling apparatus we will be able to obtain a record of the variability of the light with which we have to do. This is exactly what has been done in producing the selenium photometer for variable star work. Prof. Joel Stebbins, of the University of Illinois, has used selenium cells in astronomical work and we also find that Minchin has used these cells in several ways.

Selenium crystals have an extraordinarily high sensitivity as compared with the ordinary variety of selenium cell. With this fact in view the cells constructed for use in the selenium photometer are so made as to have a crystalline structure. From laboratory research as well as from published data, it appears that a single crystal of selenium 1 $mm.^2$ in area is one hundred times as sensitive as the best non-crystalline cell. In connection with a reflecting telescope, carrying a 36-inch mirror, such a crystal receiver could detect the light from a candle at a distance of 350 miles.

The cell is formed by winding two small enameled copper wires closely together around a flat strip of mica. (Fig. 1) Terminals are brought out from one end of each winding. This gives, in effect, two disconnected coils of wire wound side by side upon the same core. The enamel is now scraped off the top of the coils so that there is left a number of turns of two conductors spaced closely together but not touching. This arrangement is then warmed and a thin coating of the vitreous variety of selenium is spread uniformly over the wires. The strip is then placed in an oven and the temperature gradually increased to 100° Centigrade, when the vitreous selenium will rapidly begin to pass into the metallic (so-called) state, the temperature rising to about 217° Centigrade. The modification of selenium thus obtained will change its electrical resistance inversely as the amount of light allowed to fall upon it. The peculiar granular crystalline structure, so essential to the most delicate and sensitive cells, is produced by subjecting the cell to a temperature of 210° Centigrade for a considerable period of time, finally permitting the cell to cool very slowly.

Selenium appears to have no specific color sensitivity. Recent experiments carried on have shown that the character of the wavelength sensitivity curve of selenium can be controlled by heat treatment. Annealing the cell at 200° C. produces a maximum sensitivity in the red end of the spectrum, while annealing at 150° C. shifts the maximum sensitivity to 0.55μ. The distance between these crystals is shown by X-ray analysis to be in the neighborhood of 3.7×10^{-10} centimeters and the thickness of this delicate crystalline layer which is affected by the light action is calculated to be less than 0.000015 inch. From these facts it can be readily seen that in a thin layer of selenium a much higher sensitivity can be obtained than in a thick one. For this reason the photometer cells have an extremely thin coating in order that the change in conductivity may be great in proportion to the variation in light intensity. This change occurs almost instantly, or at most the in-

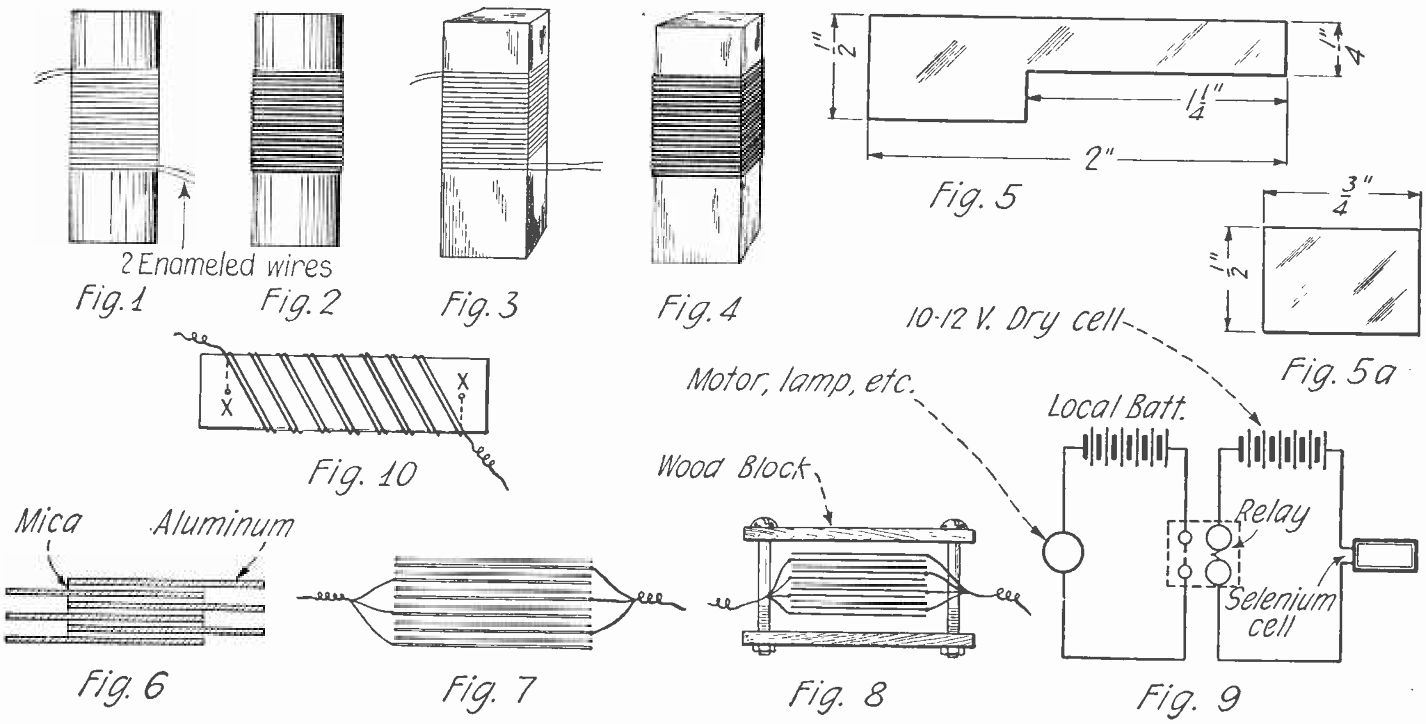


Fig. 1 Shows a Partially Wound Selenium Cell Core and Fig. 2 Shows It Completed. Figs. 3 and 4 Show Another Form of Cell Wound On a Square Core. Twenty Pieces of Thin Copper Sheet Cut As Shown In Fig. 5 Are Necessary For Making the Metal Plate Cell While Eighteen Pieces of Mica As In Fig. 5A Must Also Be Made. The Metal and Mica Plates Are Stacked As Shown In Fig. 6 and Connected As In Fig. 7 and Should Be Clamped Between Two Wood Blocks As Shown In Fig. 8. The Circuit For Testing the Cells Is Shown in Fig. 9. A Mica Sheet Cell Is Shown In Fig. 10.

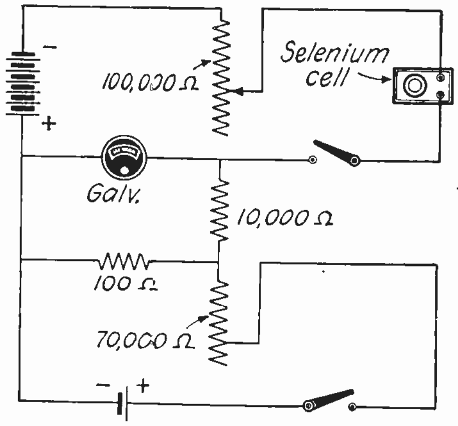
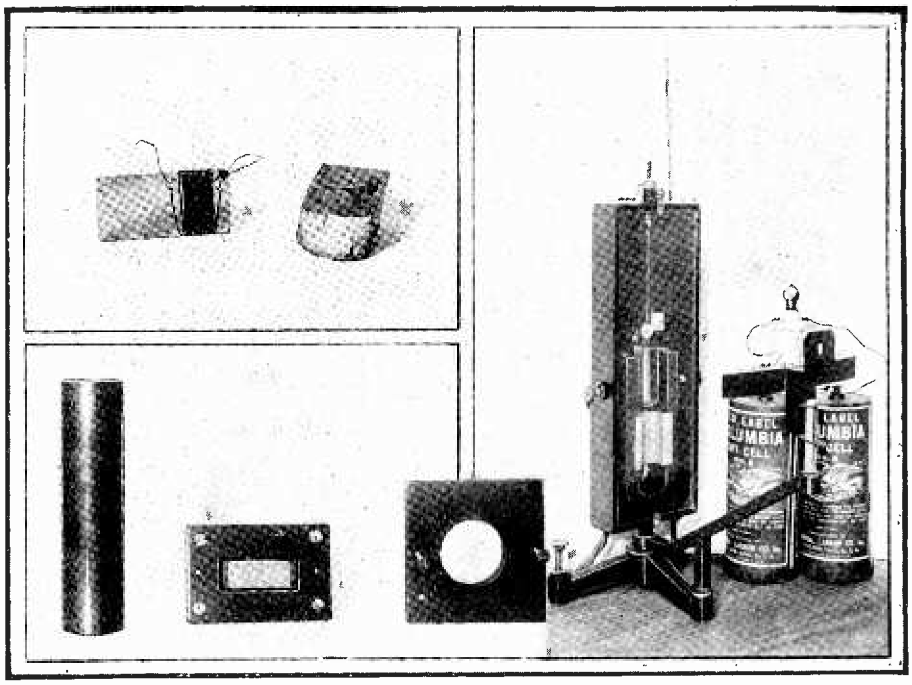


Fig. 3

Fig. 3 Above Shows Another Test Circuit For Determining the Resistance of a Selenium Cell. At Right: The Upper Left Hand Photograph Shows a Partially Completed Cell and Directly Below Is Shown the Completed Cell. At the Extreme Right Is a Photograph of the Galvano-Meter Used In the Tests.



terval of time is less than 0.01 of a second.

The selenium cell, having passed through the several processes outlined above, is now ready to be used at the telescope. It is placed in a suitable bakelite mounting and is affixed to the telescope in place of the eyepiece, by means of a short brass tube, in reality taking the place of the observer's eye. The three different parts of the cell mounting are shown in the photograph.

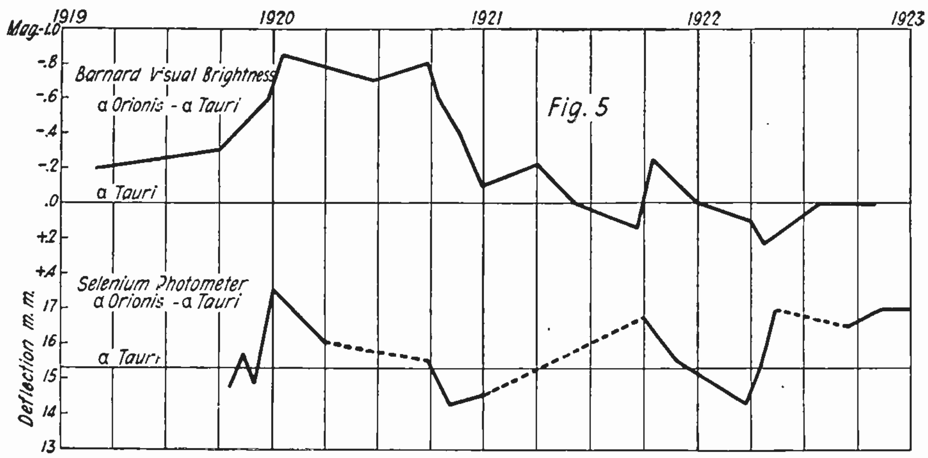
Think of it! This small selenium plate detects and indicates changes in light which left its source perhaps hundreds of years ago, traveling at the rate of 186,000 miles per second for billions and billions of miles, and finally ending its journey by speeding down the telescope tube and imparting whatever knowledge it carries to the observer through the medium of the light sensitive selenium cell.

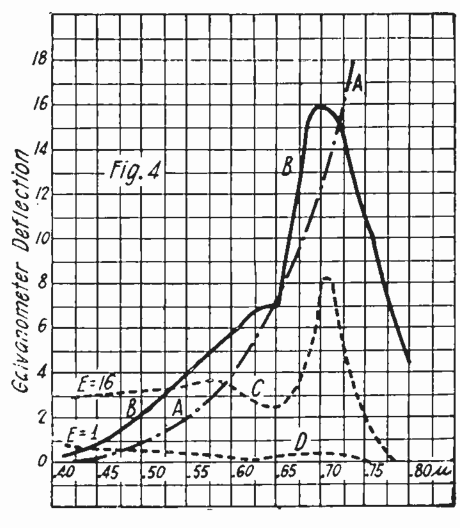
The circuit in which the cell is connected is shown diagrammatically in Fig. 3. Here the different variable resistances shown are for the purpose of balancing out certain undesirable features, such as zero shift, thermo-electric effects, etc., and also add to the sensitivity of the apparatus as a whole. In all cases the cells are slightly conducting when not exposed to light, so that the "dark current" causes an appreciable galvanometer deflection, which is annulled by passing an electric current in the opposite direction through the galvanometer. This counter-current is usually obtained by shunting across a resistance of 100 ohms, which is in series with a cell of 2 volts and a variable resistance of from zero to about 70,000 ohms. The source of light used in calibrating the cells is usually an 8 c. p. tungsten incandescent lamp, placed at a distance of 10 cm. from the cell under investigation.

Dr. Coblentz, of the Bureau of Standards, has published a curve showing the distribution of energy in the visible spectrum of the Nernst glower lamp as registered by means of a selenium cell and by a thermopile. Fig. 4, curve A, gives the spectral energy distribution obtained with a bismuth-silver thermopile (a non-selective radiometer), while curve B gives the response of a selenium cell when similarly exposed (for ten seconds) in different parts of the spectrum. Curve C gives the response that is obtained by exposing the selenium cell to equal amounts of energy in different parts of the spectrum using a high intensity, while curve D represents the response obtained at one-sixteenth the intensity used to obtain curve C. According to the measurements of Professor Pfund, for wave-lengths shorter than 0.65μ the deflections of the galvanometer are approximately proportional to the square root of the incident energy, while for wave-lengths greater than 0.7μ the deflections are approximately directly proportional to the intensity of the incident light.

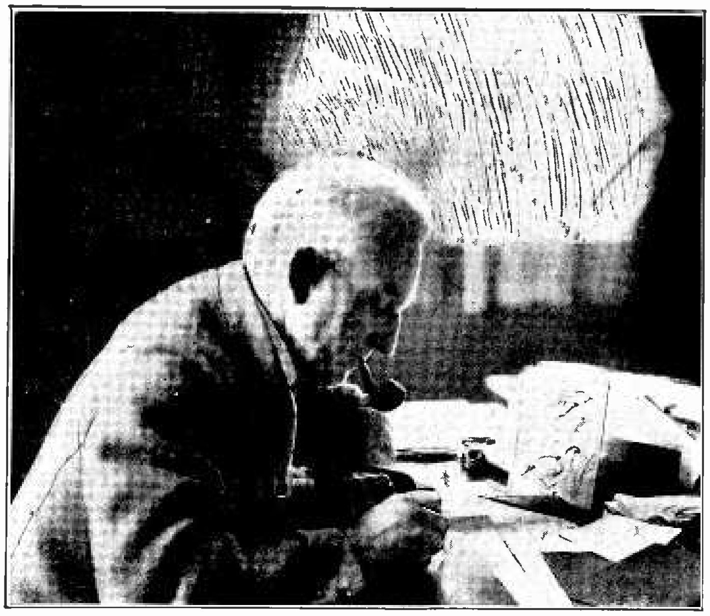
It is relevant to add that, concerning the peculiar electrical properties of selenium, some hold the view that the increased conductivity of selenium is caused by (a resonance) freeing of electrons on exposure to light. Others consider it a modification of the crystal structure, assuming that selenium occurs in several allotropic forms of widely different electrical conductivity. The absence of polarization indicates that the conduction is not electrolytic. Experiments at liquid air temperatures, where the light sensitivity is retained, seems to be evidence supporting the electronic hypothesis. The selenium cell may be used as an indicator in the null and the equal deflection methods of obtaining ratio of intensities; for example, the galvanometer deflection might be observed when the cell is exposed, say, for five seconds, to the lower intensity. Then the higher intensity is reduced, by means of calibrated crossed Nicol prisms, a wire grating, an absorption wedge, a variable sector disk, or some other device to give the same deflection. In this manner the ratios of intensities of monochromatic light of the same wave-length may be observed; but the selenium cell cannot be used in this manner to compare accurately the intensities of light of two sources differing in color. This restriction applies, of course, to all of the photo-electric devices of a like nature, as, for instance, the potassium hydride or the rubidium cell. In applying the cell to variable star observations, therefore, due care has to be exercised in compensating for the color of the star observed as well as for the clearness of the earth's atmosphere. By examining the spectrum of the star beforehand, and bearing in mind the characteristics thus revealed, the cell may be applied to a much better advantage.

(*Continued on page* 497)





The Curves In Fig. 4 Are Used In Connection With the Photometer Described Herewith and the Text Gives Full Data On These Curves. Two Curves Plotted On the Brilliancy of Stars Are Shown Above in Fig. 5.



Etching Without Copper Plates

By HARRY DUNN

IF you are an etcher and have no copper plates, or if you want to be an etcher and yet dislike to go to the expense of trying out your experimental urge of art on copper plates, just do your etching without the copper. It is being done by several artists in San Francisco, where the method was discovered by Dr. George Lee Eaton, who uses worn out and resharpened surgical instruments as needles for his etching.

A photographic plate is the substitute employed. An undeveloped plate 5 by 7 inches in size, or larger, is procured, and the picture desired is etched on that plate, the shading of the lines and spaces being accomplished by varying the depth of the cut made by the needle in the emulsion on the plate. Undeveloped plates must be used because the emulsion hardens after development, and the cutting of the lines becomes difficult, sometimes impossible. By the varying depths of the lines, delicate degrees of shading can be made and as full advantage is taken of lights and shadows as in copper-plate etching.

After the lines have been cut in the undeveloped plate, it is developed, just as in photography, except that a darkroom is unnecessary. After complete development, usually about 20 minutes, in any commercial developing solution, the plate is washed and passed into the fixing bath, as in the case of the photographic negative, and then washed and dried, when it is ready for printing. The plate, having been fully exposed to the light while the etcher is working on it, becomes impervious to light in the spaces where no lines have been drawn and light passes through only in proportion to the depth of the lines etched on it.

Dr. Eaton devised the method of etching on these plates in making anatomical drawings and surgical diagrams, as well as for sketches of unusual operations or of conditions within the body revealed by operations. He found that the result gave him a permanent negative of such pictures as he wanted, often better than could be obtained by actual photography. Thereafter, he tried out the new method as a recreation, in sketches made on automobile trips through northern California. The results indicate that, in the hands of skilled artists, pictures comparable with the work of trained copper-etchers could be produced.

One of the advantages of the negative-etching is the low cost of photographic plates compared with that of copper, and the elimination of expensive tools and the fact that etchings, drawings, plans, sketches, maps or any other sort of work done by this method may be enlarged or reduced to any size desired by merely placing the developed negatives in an enlarging or reducing camera, and printing them out to the dimensions wanted. The method is not copyrighted, and Dr. Eaton has given it to the art associations of San Francisco, where several etchers have experimented with it with good results.

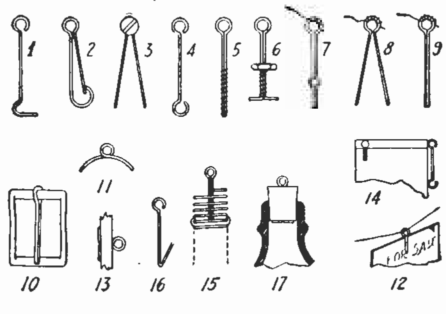
The Photograph Above Shows Dr. George Lee Eaton, Discoverer of the New Method of Etching. At the Right Is One of Dr. Eaton's Etchings Showing a Lake In Lake County, California, Which Was Printed On Ordinary Photographic Paper From the Glass Negative.

When the plate is thoroughly dry, it is placed against printing-out paper, in a printing frame, and printed by electric or sunlight, just as a photographic negative would be printed, except that the average exposure to the light is less than in the case of an ordinary negative. The result is a perfect print of the etching made on the emulsion. Some of the etchings so printed on brown and green printing-out papers have been remarkably beautiful, and, as the new art is still in its infancy, probably other improved coloring methods will be developed.

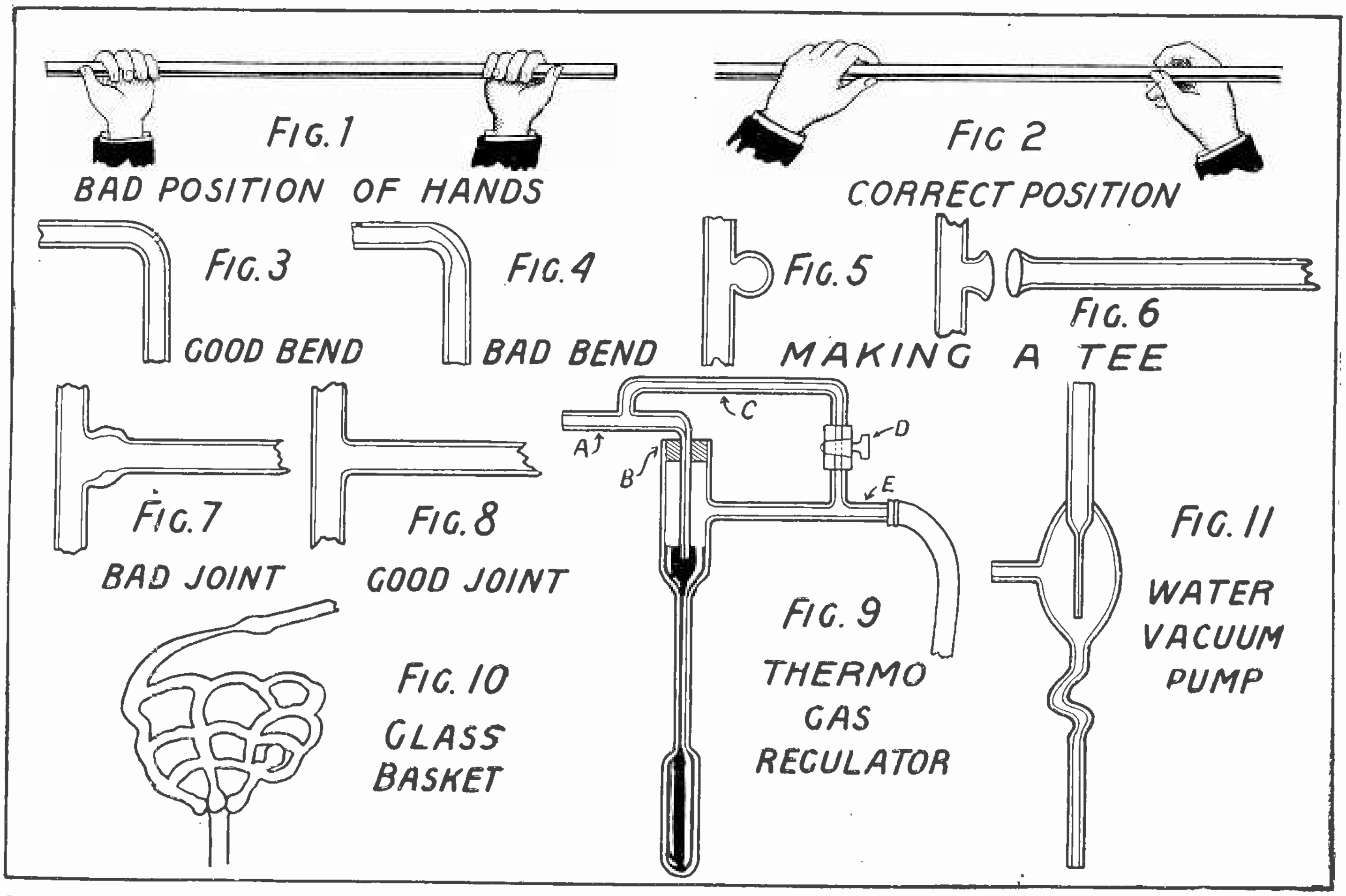
Uses For Cotter Pins

Many are the uses to which split keys or cotter pins can be put. As a matter of fact very few people realize just how important these little accessories are, primarily because of the fact that they have only attempted to use them in or around machinery. The cotter pins, however, may be employed as hooks for small doors or boxes, by merely clipping off a portion of the pin and bending the other to make it conform with the hook shown in Fig. 1. If instead of cutting off half of the pin we shorten one limb and bend the other portion around it, we have a miniature snap hook which may be employed in models, or may, in a pinch, even replace snap hooks on harness. A use for cotter pins that is very often overlooked, is illustrated in Fig. 3. The cotter pin is fastened to the wall with a screw; it will hold a spool of cotton when slipped over the legs. For repairing thin chains, the method employed in Fig. 4 will be found of value. It is very difficult to obtain eye bolts when needed, particularly the smaller sizes, but they may be made from cotter pins very easily, as shown in Fig. 5. By placing a nut and washer upon the eye bolt and then spreading the legs, a toggle bolt, Fig. 6, is produced.

Figs. 7, 8 and 9, show methods of making connection clips. Fig. 8 is very serviceable in small receivers where the spread clip will hold itself in the binding post holes without necessitating tightening of the nuts. A method of repairing a buckle by merely slipping a cotter pin over the major portion is shown at 10, and 11 indicates a line guide for fishing rods or a single sight for .22 calibre rifles. If a number of these cotter pins, Fig. 12, are strung upon a wire, they make very serviceable card holders. The cards can be removed at any time without much difficulty, and may be replaced again without removing the cotter pins from the line. A clinched eye for locks on chests, thin doors, or for hooks, is shown in Fig. 13. By bending the cotter pin at right angles and driving it edgewise into a box, it makes a very fine hinge, a screw in the cover acting as the pivot point. This is shown in Fig. 14. Repairs for many kinds of springs can be made with the cotter pin if the legs are bent out, as illustrated in Fig. 15. The tension of the spring can be increased by merely turning the cotter pin into the spring for a greater distance. Another card holder, but one which is detachable, is shown in Fig. 16, and last but not least, we find the use depicted in Fig. 17 for preventing jug corks from being broken by too frequent extractions with a corkscrew or from being lost. A cord is passed through the cotter pin and tied to the neck of the jug. A tug at this cord will then remove the stopper, which being attached to the neck of the bottle by means of the cord, cannot be misplaced. Contributed by C. R. MULLIN.



Many Uses For Cotter Pins Are Shown In the Above Illustrations and Many Others Will Probably Be Suggested To the Reader By His Ingenuity.



Figs. 1 and 2: Incorrect and Correct Positions for Rotating Glass Tubes in Flame. Figs. 3 and 4: How to Make a Good Right-Angle Bend, and the Result of Incorrect Manipulation. Figs. 5 and 6: Making a Right-Angle Joint. Figs. 7 and 8: The Correct and Incorrect Appearance of a Finished Joint. Figs. 9, 10 and 11: Examples of Glass Work Which Can Be Accomplished With a Little Patience and the Correct Manipulation of the Glass.

Glass Blowing In the Laboratory

By ISMAR GINSBERG, B. Sc., Chem Eng.

THE art of glass blowing is comparatively simple, provided one keeps in mind certain fundamental principles of the art.

Glass is a material which is thickly fluid under a high heat. But this heat is so great that it can best be obtained by the blast lamp and rather soon after the glass is removed from the flame of the lamp, it hardens and can no longer be worked properly. The greatest difficulty that the beginner finds in glass blowing is to shape the glass into the different forms he wishes it to assume, while the glass is in the proper pasty condition. If you attempt to blow a cold glass, uneven results are obtained. Furthermore, it is necessary in working with glass that the blowing be done easily and uniformly. It does not pay to lose one's patience and blow rapidly. If that is done, forms are obtained which are far from what are desired. A few tools are used in glass blowing, but generally the glass blower makes very little use of them. All he needs is a good blast burner and a triangular file for nicking the glass so as to break it off.

In blowing glass in the laboratory for the ordinary uses that arise from time to time therein, the chemist should know how to bend glass tubes so that the bore is not materially diminished in the bending operation, how to blow bulbs, and how to fuse glass at the end of the apparatus, at the side and internally. The rough edges can then be removed by a little grinding or by simply fusing the glass in the flame.

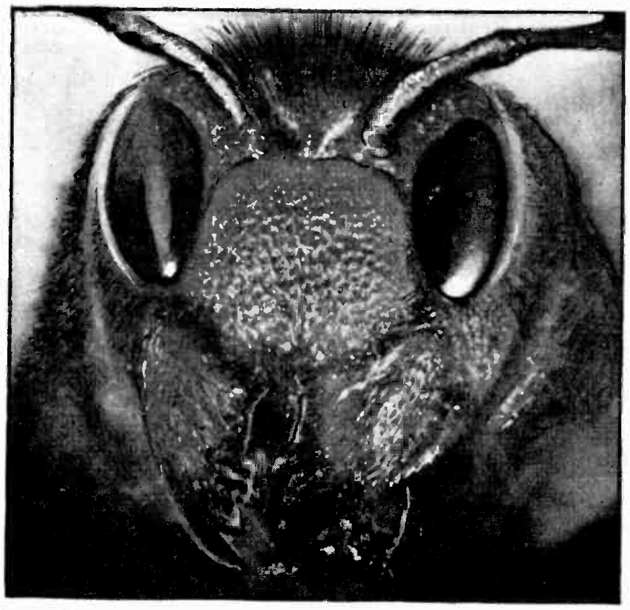
The principal piece of apparatus is the blast lamp. After the flame has been adjusted so that its height is not too great and the inner blue cone is fairly large but well distributed through the mass of the flame, the glass tube, that it is desired to bend at right-angles for example, is held in the flame just a little above the tip of the inner cone and allowed to heat up. It is kept in constant rotation while the heating is going on. In this stage of the operation the position of the hands is of the highest importance. In fact the success of glass blowing depends to a large extent on their correct position.

A GOOD QUALITY GLASS SHOULD BE EMPLOYED

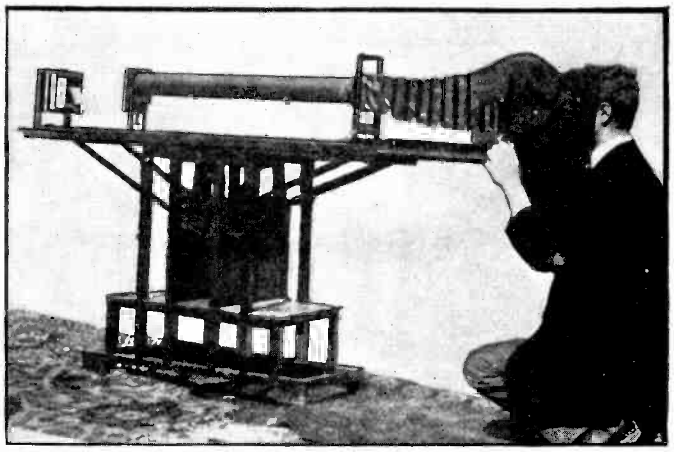
The correct position of the hands is such that the left hand grasps the tube lightly with the palm in front. The tube is held between the thumb and the other fingers. The tube can thus be rotated continuously and regularly by a simple movement of the thumb and fingers. The other end of the tube is held between the thumb and the index finger in the right hand with the palm extending away from the glass blower.

In heating glass prior to blowing or formation into various shapes, it often happens that due to an irregularity in the glass, the flame or due to accidental moving of the hands, the heated part becomes slightly deformed; it gets out of shape. The beginner in this case generally tries to correct the fault by continuing heating the glass. But this just serves to complicate things, to accentuate the deformity and finally render the fault so bad that it can no longer be remedied. The only practical thing to do is to continue the heating and gradually draw out the glass to a fine point and then to insert the open end of the tube in the mouth and without twisting the tube to blow gently. The deformation is automatically corrected in this manner.

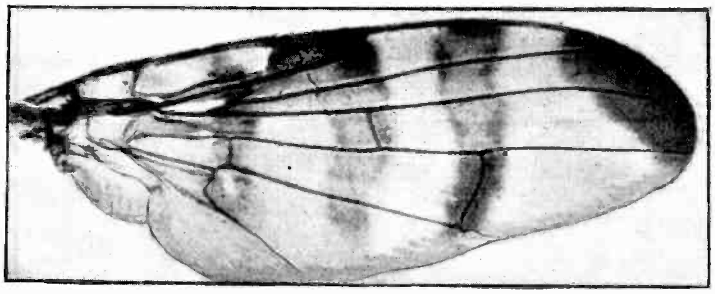
Another error which novices generally make is to suppose that the joint between two pieces of glass would be more solid, if the thickness of the glass were thicker. They therefore tend to accumulate a mass of glass at the point where the joint is to be made by prolonged heating. But in reality instead of being stronger, the joint is actually more fragile. For in cooling off the inequalities that arise due to the contraction that takes place in the glass mass result in the development of internal forces which act and counteract, and inevitably cause the glass to break. In making a good joint between two pieces of glass, as for example in joining a glass tube laterally to another tube or to a bulb, just a few simple rules must be followed to obtain success. The two parts, that are to be joined together, must be heated rapidly one after the other. The flame of the blast lamp must be large. Then the two pieces are brought together and the molten parts of the glass are allowed to make contact. Only one piece is supported, the other hangs from the first in an unsupported position. Then the pieces are pulled slightly as if it were desired to separate them. Air is blown through the tube while it is being uniformly turned while being heated in the flame. If these directions are followed out assiduously the joint is perfect and indeed in many cases it is impossible to tell where union took place.



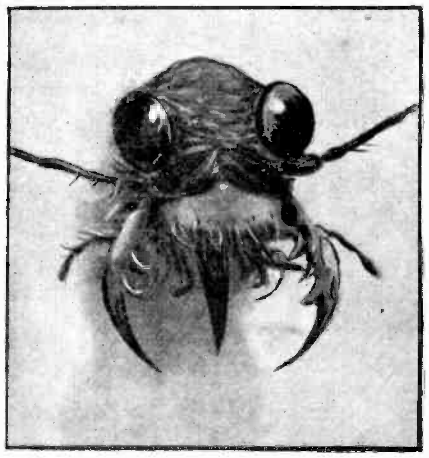
This Seeming Monstrosity Is Merely the Head of a Digger Wasp Enlarged Directly, By Means of the Camera Described Herewith.



The Camera By Means of Which the Enlarged Photographs Illustrated Herewith Are Taken.



An Enlarged View of a Wing Taken From a Peacock Fly. Any Amateur Can Duplicate This Work With the Camera Illustrated in the Upper Right Hand Corner.



A Photograph of the Head of a Tiger Beetle Enlarged Ten Times

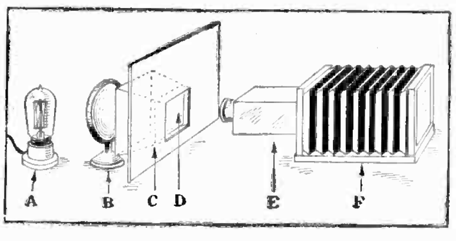
How to Use Your Camera

By DR. ERNEST BADE

NO. 8. VARIOUS WAYS OF ENLARGING PICTURES

THE cameras used by the amateur usually produce only small pictures. It is, of course, possible to enlarge these, but then the negative must be sharp and contrasty. Under no conditions will such an enlargement produce all the fine and delicate details found on the smaller negative. The greater its enlargement, the more will it lose in distinctness, and if the enlarging is pushed too far, then the silver grain of the emulsion will become too pronounced. An enlargement should not be made if it can be avoided, although certain types of artistic photos, which require a soft, half concealed effect, can be thus obtained. In other cases it is far better to take the picture in the desired size at once. If the bellows extension is not long enough, then an extension can be added, such as was mentioned in the first article. With an exceptionally good lens of wide aperture such hollow extensions, consisting of tubes or sections of square boxes which fit light-tight, can be made to a length of about 8 to 12 feet depending upon the focal length of the lens, or until an enlargement of approximately 12 diameters has been attained. This is also sufficient to take pictures of minute objects directly, such as insects, etc.

On the other hand, an exceptionally great enlargement can be obtained by photographing small objects directly if the lens of the camera is removed and an ordinary well ground hand or reading glass, a double or plano-convex lens being best adapted, is substituted. The most even illumination is obtained by having the source of light immediately behind the microscopic object. Electric light is best, and between light and object, a ground glass is placed which will illuminate the object more uniformly. The exposure is usually less than ¼ of a minute.



A, Light. B, Condensing Lens. C, Ground Glass. D, Opening in Cardboard Screen. E, Enlarging Extension. F, Camera Using Bromide Paper, In Place of Films.

Best results are obtained by using a lens larger than the object to be taken.

ENLARGING WITH A PHOTOGRAPHIC OBJECTIVE.

Enlarging with the photographic objective by the aid of one or more bellows extension sections will give quite a little depth, especially if the iris diaphragm is closed down. Such pictures are best taken out of doors in the direct light of the sun, the strong shadows being softened with the aid of a little mirror. With a long extension and with closed diaphragm an exposure of about a minute is necessary.

When light is transmitted through the negative so that an enlarged image is thrown upon the ground glass of the camera—using either the simple lens or the camera objective—the image can be taken directly upon bromide paper which, of course, will give a positive or print of the small negative used. Here the bromide paper is placed in the ordinary plate holder and exposed like a film or glass plate. The process of loading and developing must be carried out in red light. If it is desired to enlarge with reflected light, then a print of the negative must be taken and this must be enlarged upon film or glass plate.

HOW-TO-MAKE-IT

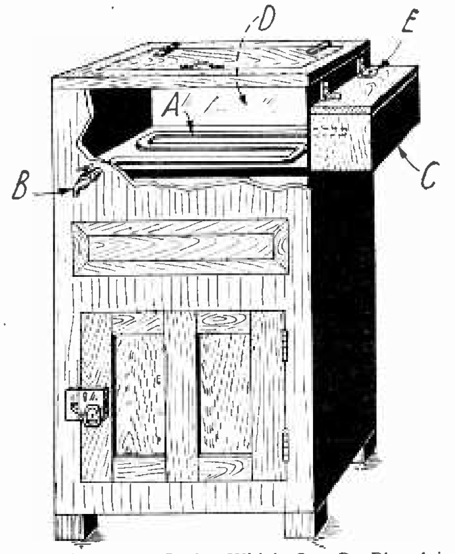
This department will award the following monthly prizes: First prize, $15.00; second prize, $10.00; third prize, $5.00.

The purpose of this department is to stimulate experimenters toward accomplishing new things with old apparatus or old material, and for the most useful, practical and original idea submitted to the Editors of this department a monthly series of prizes will be awarded. For the best idea submitted a prize of $15.00 is awarded; for the second best idea a $10.00 prize, and for the third best a prize of $5.00. The article need not be very elaborate, and rough sketches are sufficient. We will make the mechanical drawings. Use only one side of sheet. Make sketches on separate sheets.

FIRST PRIZE $15.00

WATER COOLER FOR THE ICE BOX

During the summer months cold water is a vital necessity. No matter where you are, cold water is a refreshment which has no equal. At home, as many of you who have small refrigerators know, it is no simple



A Handy Water Cooler Which Can Be Placed in an Ordinary Ice Box and Which Will Supply Free Cold Water.

matter to have cold water, for the obvious reason that to keep water bottles continually cold is very inconvenient, while to place a box full of water into the refrigerator, is utterly impossible, due to the lack of space.

As I am the owner of a small refrigerator, I worked out the following scheme. After having a tinsmith make me a zinc box 14" in length, 4" wide, and 8" high, with a cover, I took a lead pipe 3/8" in diameter and about a yard long, and bent it into the shape shown in the drawing. After fastening the box to the side of the refrigerator by means of screws, as shown in the illustration, I attached the faucet B to the front end of the pipe. This done, I put the other end of the pipe through a hole in the box C. Then I secured a piece of galvanized tin, the size of the ice compartment, and covered the pipes to prevent them from being dented when the ice was put in. The operation of the above device is as follows. Water is poured into the reservoir box C, thus causing the pipe to be filled with water, which is cooled by the ice on top. Due to the fact that the pipe is long, a goodly amount of cold water is on hand at any time.

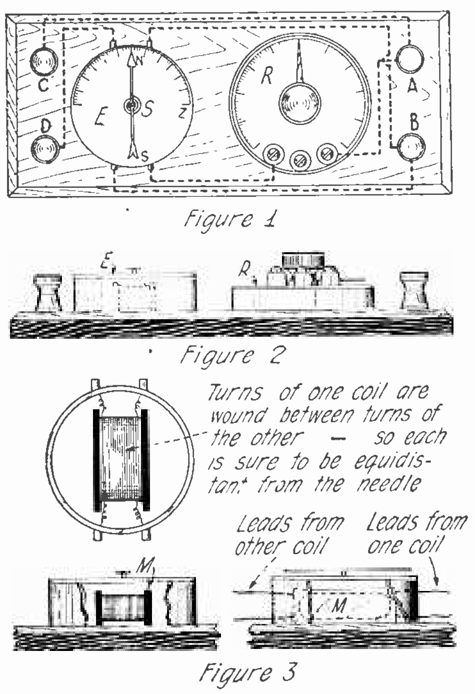
Contributed by JACOB SCHMIDT.

SECOND PRIZE $10.00

RESISTANCE FINDER

Most experimenters cannot afford to buy a good Wheatstone Bridge, and are therefore, greatly handicapped in performing many experiments. The resistance finder, here described, can be made very cheaply (for about $3.00 or $4.00), and can be employed to measure resistances quite accurately. It consists mainly of a calibrated rheostat or rotary potentiometer, having a resistance as high as you want to measure. A galvanometer with two coils of wire, wound on the same bobbin but in opposite directions is also necessary. Both coils must be of the same size of wire, and have exactly the same number of turns. The galvanometer with the location of the coils is shown in the illustration. The needle of the galvanometer is poised directly above the coils of wire. A small watch spring S, holds the pointer at the zero position on the scale indicated at Z. The instruments are mounted on a board of convenient size, with four binding posts, and connected as shown. To find the resistance of any instrument or length of wire which is likely to be within the range of the instrument, which in this case is 0-300 ohms, the unknown resistance is connected to binding posts C and D, while a dry battery is connected to A and B. The needle of the galvanometer will swing to the right or left, depending on which coil is carrying the most current. Since the current flowing in one coil is determined by the resistance across C, D, and in the other by the resistance at R, and as the resistance at C-D, is invariable, the two circuits can be brought to equality by varying the resistance at R. As soon as the circuits are adjusted correctly, the needle of the galvanometer will be at the zero position. This indicates that the resistance at R is equal to that at C-D; whatever resistance the pointer of the rheostat indicates, is also the unknown resistance.

Contributed by TRUEX BUCK.

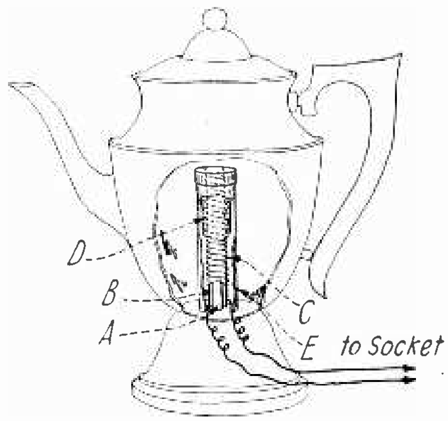


An Instrument Designed for the Experimenter by Means of Which he Can Calibrate His Own Electrical Resistance.

THIRD PRIZE $5.00

SEALING COMPOUND HEATER

A very handy sealing compound heater can be easily built by the amateur. A discarded coffee percolator is first secured, and in the bottom of this a fitting for an iron pipe 3/8" in diameter and about 5½" long is fastened. This iron pipe is covered with mica or asbestos, and then wound with No. 26 iron



An Apparatus for Melting Sealing Compound so That it Will Always Be Handy and Ready to Use.

wire. About ten feet of wire will be required. The turns should be spaced one-sixteenth of an inch apart. The coil or winding is then insulated on the outside with asbestos, whereupon the entire device is slipped into a ¾" pipe and caps are screwed over either end, holes being drilled in the top end to permit passing the wire through the same. Leads are connected to the heating element and the percolator is filled with broken pieces of sealing compound, which may be heated up by simply turning on the current. The temperature will be maintained fairly constant.

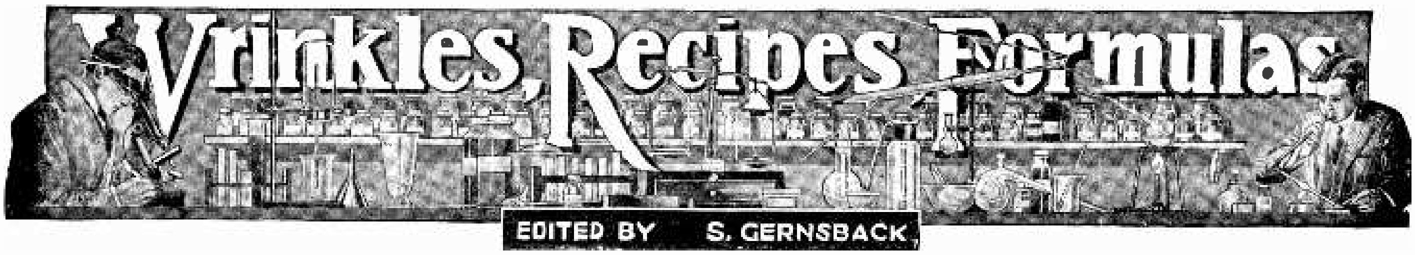
Contributed by ANTON LUTONSKY.

COLD SOFT SOLDER

Ethyl acetate is first made by distilling a mixture of 20 parts of acetic acid, 10 parts sulphuric acid and 6 parts ethyl alcohol. Sealing wax is added to this distillate until no more will dissolve. Then, finely, powdered aluminum is added, a little at a time with constant stirring, until a stiff paste is formed. This compound thus made, is not exactly a solder, but a metallic cement which will withstand heat. It will mend holes in steam, water and gas pipes, also in aluminum agate and iron cooking utensils. It should be rubbed smoothly over the hole with a flat stick, while a piece of paper is held on the other side. It is very strong as a cement, and when it is used on cooking utensils, the finely powdered aluminum fuses together.

The solder should be kept in an airtight container and never brought near a flame.

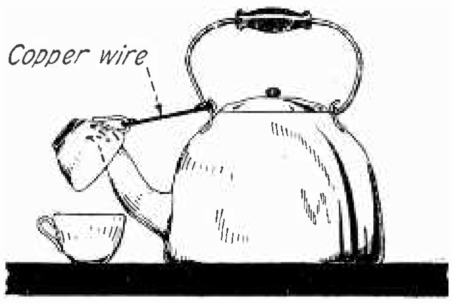
Contributed by ALDEN JOHNSON.



THIS MONTH'S $5.00 PRIZE WINNER

SIMPLEST STILL

This is a very simple method of making a still which I have found to be quite efficient. The substance to be distilled is placed in an ordinary kettle, and a tumbler is inverted over the spout and held there by means of a piece of wire. Beneath this tumbler another is placed. The spout of



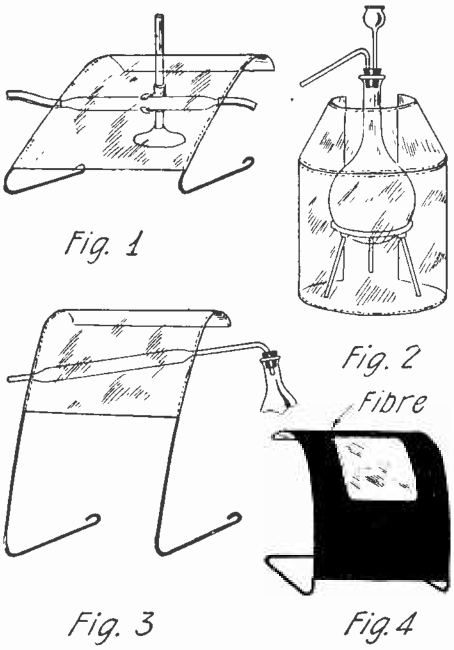
A Simple Still May Be Made By the Use of Two Cups and a Tea Kettle.

the kettle should be preferably directed over the edge of the stove, so that the liquid receiver will not rest upon the stove itself. It is not suggested that alcoholic liquors be distilled in this type of apparatus, because of the inflammable nature of the distillate.

Contributed by SIMON KESSLER.

SHIELD FOR EXPLOSIVE MIXTURES

When experimenting with gases, there is in many cases, the possibility of an explosion. This means that the experimenter, unless he has some means of protection, will nine chances out of ten, receive a charge of



Every Experimental Chemist Should Use One of These Shields When Performing Experiments With Explosive Mixtures.

splintered glass in his face and eyes. It is to prevent such a catastrophe, that the shield described below is designed. This protector consists simply of several layers of clear mica securely fastened to a stiff wire frame. As shown in the drawing, the shield is placed in front of or around the mixing tube or generator. The materials of which it is constructed are very easily workable, and an almost unlimited variety of sizes and shapes can be made. A good clear grade of mica, which can be purchased from any automobile supply house, is wired through holes punched near the edges to the frame, bent to the desired shape. Three or four layers of the mica should prove strong enough to deflect the splinters of a standard weight test tube or burette. The shield should be placed several inches from the apparatus. The illustration shows a shield for use where a partial obstruction of view is not objectionable. It is constructed of heavy fibre, and contains a mica window. When buying the mica, one should be certain that he is geting the genuine mica, and not some inflammable celluloid substitute.

Contributed by B. E. DE MARE, JR.

HOW TO MAKE A COLLOIDAL GOLD SOLUTION

The study of colloids is an interesting side of chemistry and a subject that is receiving a great deal of attention today.

A colloidal gold solution is easy to prepare provided you have some gold chloride to start with. Those who do not have this expensive salt can prepare a very satisfactory solution by looking around the house for a gold filling that has come from a tooth of some unfortunate member of the household. This small piece of gold is dissolved in aqua regia (1 part Nitric Acid to 3 parts Hydrochloric Acid). The volume of this solution should be about 10 c.c. (Cubic Centimeters), depending somewhat upon the original size of the gold filling.

Add about 5 drops of this gold solution to 50 cc. of water in a test tube. Test the solution with blue litmus paper and if it turns the paper red add a little baking soda to make the solution neutral.

With our now neutral gold solution it is an easy matter to reduce the gold to a beautiful suspension of colloidal particles. This is done with a dilute solution of Formaldehyde (1 or 2 drops of the commercial formaldehyde to 50 cc. of water).

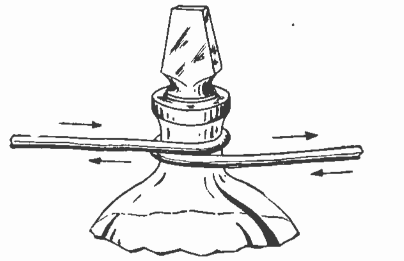
Heat the solution of gold nearly to boiling and add 1 or 2 cc. of the dilute formaldehyde solution which acts as a reducing agent. The solution assumes a red or purplish color depending upon the size of the gold particles formed. By varying the concentration of the gold solution and the amount of reducing agent used different shades of colloidal gold can be produced.

These solutions will usually last for a long time, especially if the gold used was pure to begin with.

Contributed by J. V. CRANDALL, M.S.

LOOSENING TIGHT GLASS STOPPERS

The glass stoppers of certain bottles, especially those containing alkaline substances, often become fastened so tightly that even jarring will not loosen them. However, if the neck of the bottle is heated, it expands, easily loosening the stopper. The ordinary methods of heating are very liable to crack the glass, but if a strong cord, or better, a flat shoe-string is wound once about the neck (see figure) and run vigorously back



Tight Glass Stoppers May Be Loosened By Means of a Cord As Shown Above.

and forth while the bottle is held firmly, sufficient frictional heat is developed to loosen the most obstinate stoppers with no danger of breakage.

Contributed by CHAS. D. TENNEY.

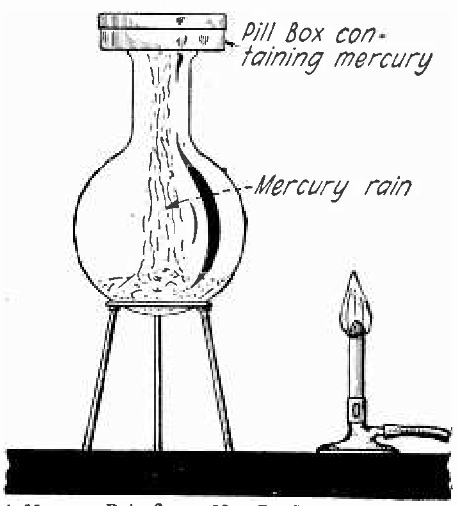
THE MERCURY RAIN

This experiment, one of the many devised to show the almost inconceivable pressure of the air, has hitherto been beyond the scope of the average experimenter.

Cover the bottom of a heavy, 500 cc. flask to the depth of a quarter of an inch with water. Support it over a square of wire gauze on a ring stand and heat to boiling. While the water is heating, pour 10 or 15 cc. of mercury into a small, round box, turned from wood. The grain of the wood should run parallel to the axis of the box.

Remove the heat and the instant the water stops boiling, place the box on the rim of the flask. As the apparatus cools, the steam in the flask condenses, creating a partial vacuum. The mercury is forced by atmospheric pressure through the pores of the wood and rains into the water.

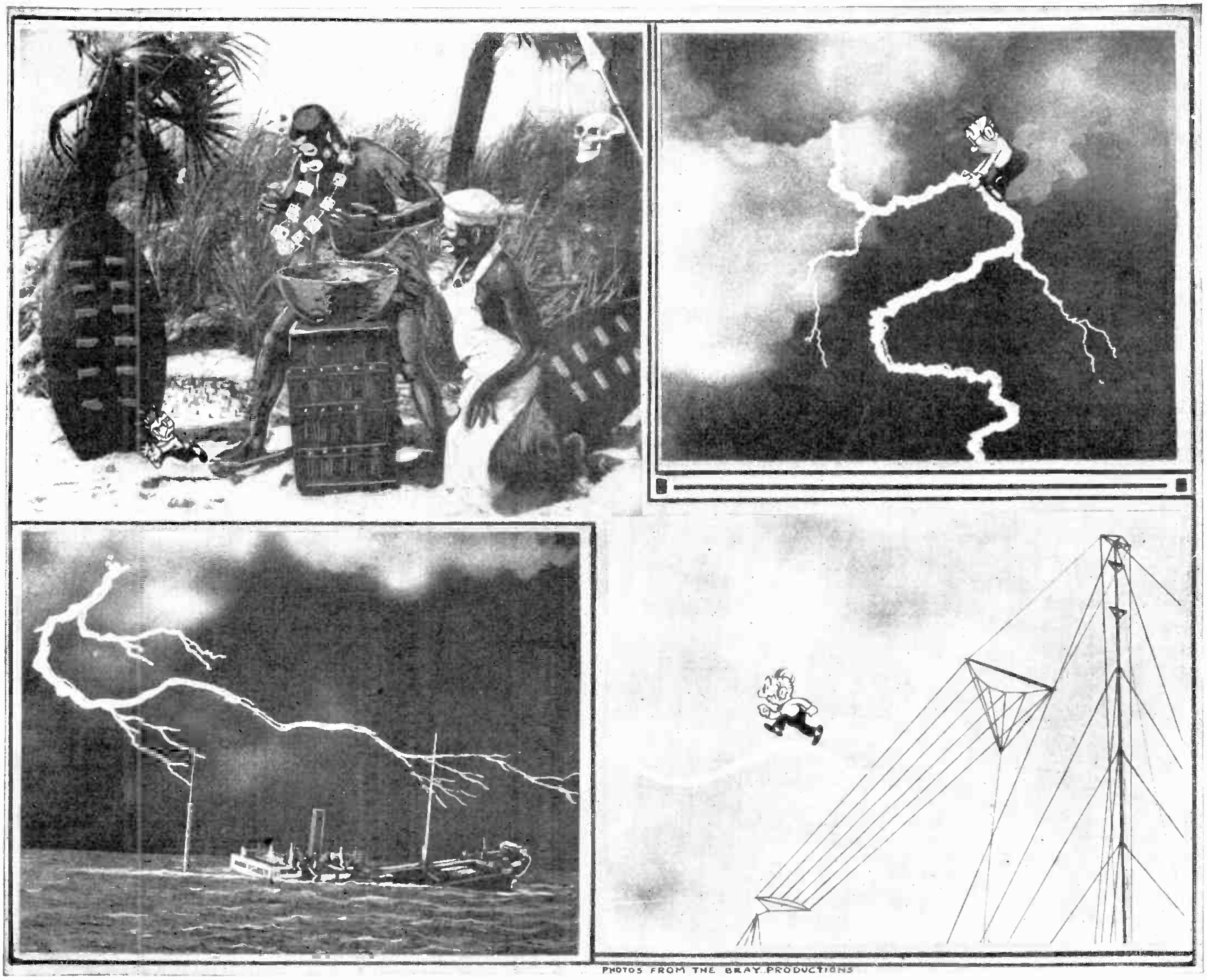
Contributed by CHAS. D. TENNEY.



A Mercury Rain Storm May Be Created By Means of a Pill Box and a Partial Vacuum.

RADIO BROADCAST

Colonel Heezaliar Flirts With Radio



Upper Left Hand Photo Shows the Cannibals Trying to Stamp Out Col. Heezaliar's Life. Below This the Ship Struck By Lightning Is Rapidly Sinking. Upper Right Hand Photo Shows Heezaliar Sliding Down the Lightning, and the Photo Below Illustrates How He Ran On the Radio Wave.

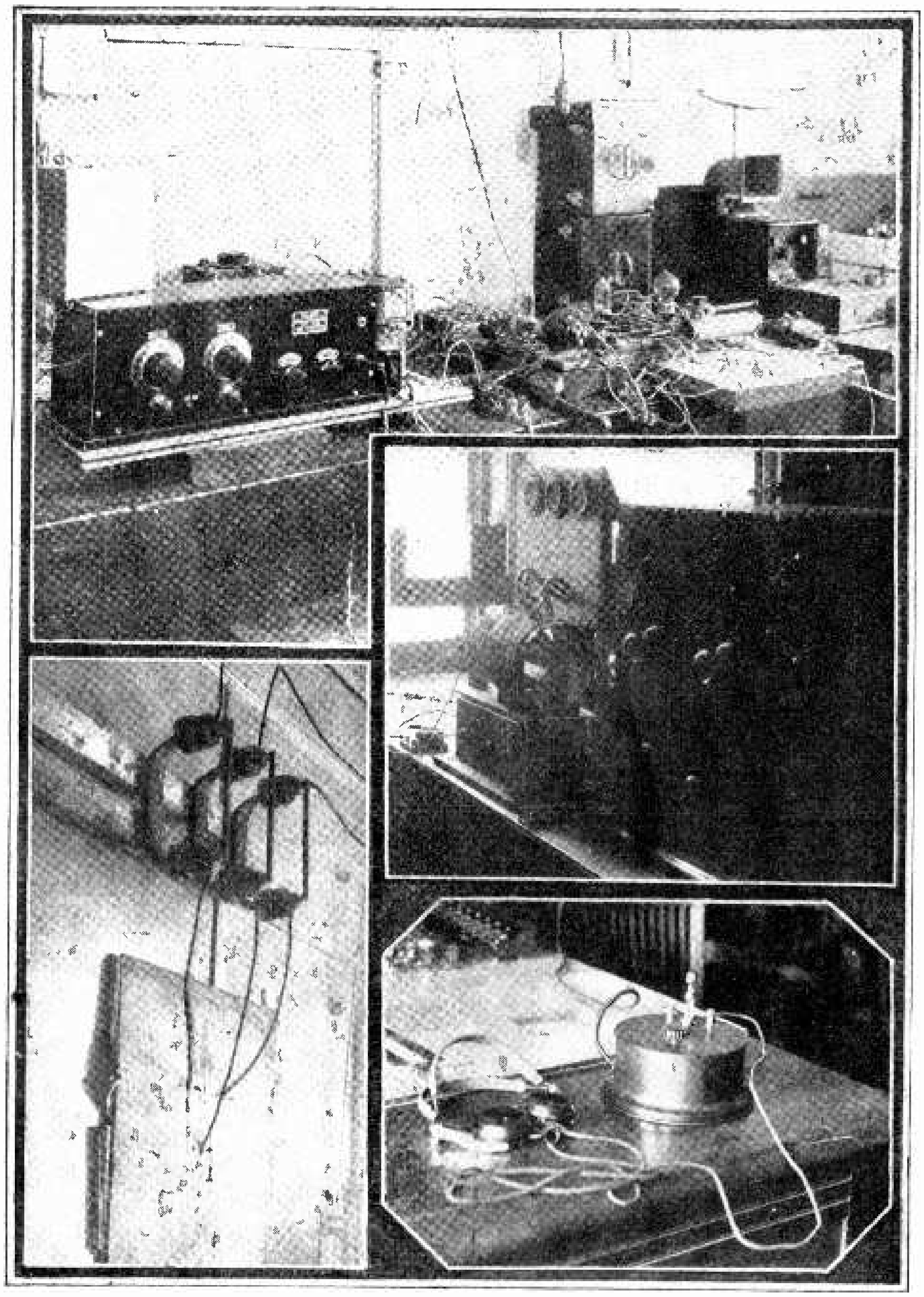
VERY startling effects can be produced by combining cartoons with motion pictures. For instance, in one of the Colonel Heezaliar films we see the artist sketching the Colonel. The artist then draws a lake and the Colonel intimates that it is too hot to work, so he dives into the lake and swims around. The artist meanwhile has his attention distracted by a report in the newspaper that a great many vessels have sailed for Treasure Island and expect to find hidden gold there.

The Colonel becomes a nuisance in his efforts to determine what the artist is reading, and is forcibly thrown against the easel from which he has escaped. Desiring revenge he slides from the easel again and makes his way to an open window. By crawling and jumping he disappears through the window and reaches the roof where a radio station and its operator are found. Here he informs the operator that he would like to be placed on a ship near to Treasure Island, and desires to be transmitted there by radio. The operator picks up Colonel Heezaliar, pastes him to a cardboard and pushes him into a slot conveniently located in some peculiar part of his grotesque transmitting station, and then presses the key. On the roof of the building one can see a picture of the antenna and the undulating current being emitted therefrom. Suddenly the lead-in commences to swell progressively, and Heezaliar wobbles out through the top of the L-type antenna and runs along the wave.

We cut in now to a scene where a ship is sinking in mid-ocean. Heezaliar, who has been shot into the clouds by the radio wave, decides to leave them, and when the proper bolt of lightning flashes from the sky striking the ship, and straightens out to form a very fine sliding pole similar to the ones used by the firemen in their company houses. Heezaliar slides down and lands on the deck of the sinking vessel, which is, by the way, nearest to Treasure Island. On the vessel but a short while, Heezaliar realizes that it is impossible to stay there as the ship is sinking rapidly. He makes his get-a-way in a bottle cast upon the waves, and is washed ashore on a cannibal island. One of the cannibals scouting the beach discovers the bottle, and extracting the cork therefrom, withdraws the Colonel. Throwing him to the ground he attempts to step on him, but Heezaliar eludes the cannibal's feet. Eventually captured, Heezaliar finds himself in a cauldron for the next meal. *Photos courtesy of Bray Productions.*

Utilizing Wired Radio for Broadcasting

By BERT T. BONAVENTURE



Top: A Loop Receiver For Relaying Radiophone Broadcasting From the Receiving Antenna to the Electric Light Line. Lower Left: The Condenser Arrangement for Feeding Wired Radio Messages Into a Three Phase Transmission Line. Upper Right: Experimental Transmitting Apparatus for Wired Radio. Lower Right: Crystal Receiver With Tuning Condenser for Reception of Wired Radio From the Electric Light Lines.

IT has remained for the present chaotic condition in the broadcasting situation to bring into due prominence some of the actual work being done in utilizing the transmission lines of a central power station for radio communication purposes, an idea advanced as early as 1911. Wired radio, as the name suggests, is a scheme of transmitting currents of high frequency along a system of conductors which then serves as the connecting link between the transmitter and the receiver. In space radio, the transmission medium which serves the above purpose is the hypothetical ether.

Wired radio is the invention of Major-General George Owen Squier, Chief Signal Officer of the United States Army. An active interest has been shown by Maj.-Gen. Squier in the present as well as in past experiments and tests of his system.

In order to collect the necessary data, before placing the system into commercial use, exhaustive experiments had to be carried out to determine the peculiarities, if any, in the characteristics of wired radio transmission. For this purpose, a series of extended tests were carried out in various cities such as Cleveland, New York and Washington, D. C. The co-operation of the Radio Section of the Bureau of Standards was obtained in the last mentioned city. As a result of these experiments interesting observations were recorded, which proved of considerable value when the commercial project was launched.

Some apprehension was felt from the start relative to the character of the light and power distribution system. The method of distribution of electric light and power generally utilized in most cities where alternating current is used is as follows: Primary generation of current takes place at the central station at voltages ranging from 5,000 to 15,000 volts, three phase, and is distributed to the several substations at this voltage. At the substations this current is transformed to between 2,000 and 3,000 volts, also three phase, and redistributed to the areas where the consumers are located. The various distribution transformers located along the line reduce the voltage to approximately 110 volts, single phase, in which form it is finally used. In order that the broadcast service be supplied to the maximum number of customers with the minimum losses occurring in the intermediate power apparatus connected to the line, it is necessary for the transmitter to operate into the 2,000 to 3,000 volt line.

It had been a relatively easy task to transmit by wired radio over a long transmission line, where an unobstructed flow was offered to the high frequency currents from the transmitter to the receiver, the line providing a direct path for the signal.

Furthermore, it was found that with the proper choice of wave-length for any given installation practically all of the energy transferred to the line would be propagated to its destination by conduction and no appreciable amount of energy would be lost by radiation in the form of electromagnetic waves. From a study of the theory, it was expected that with decreasing wave-lengths, the attenuation suffered by the transmitted energy would increase and that abnormally large powers would have to be used to cover a given distance. However, actual tests showed that extremely long wave-lengths gave very poor results and that an optimum wave-length exists at which no appreciable radiation into space occurs, at the same time the same wave-length provides good wired radio service. During tests on one line, short wave-lengths up to 710 meters gave considerable radiation as evidenced by reception on an antenna, while 13,000 meters gave poor reception on an antenna and also by wired radio, showing, in this case, that the wave-lengths chosen were ill fitted to be used successfully on that particular line. Excellent wired radio reception, with almost nil reception on an antenna was obtained when using a wave-length of 3,800 meters.

When using short wave-lengths, the existence of "blind spots" was relatively frequent. At these spots no reception could be obtained, due apparently to the fact that standing waves were formed through the reflection of the high frequency currents by the power apparatus on the line. At the nodes of these stationary waves no reception was possible, while maximum signal strength was obtainable at the loops.

At the present time, the Richmond Light and Railroad Company of Staten Island, New York, has a wired radio broadcasting station in operation at the Livingston power house. Special receivers, both crystal and vacuum tube type, have been developed for use on the company's electric light lines.

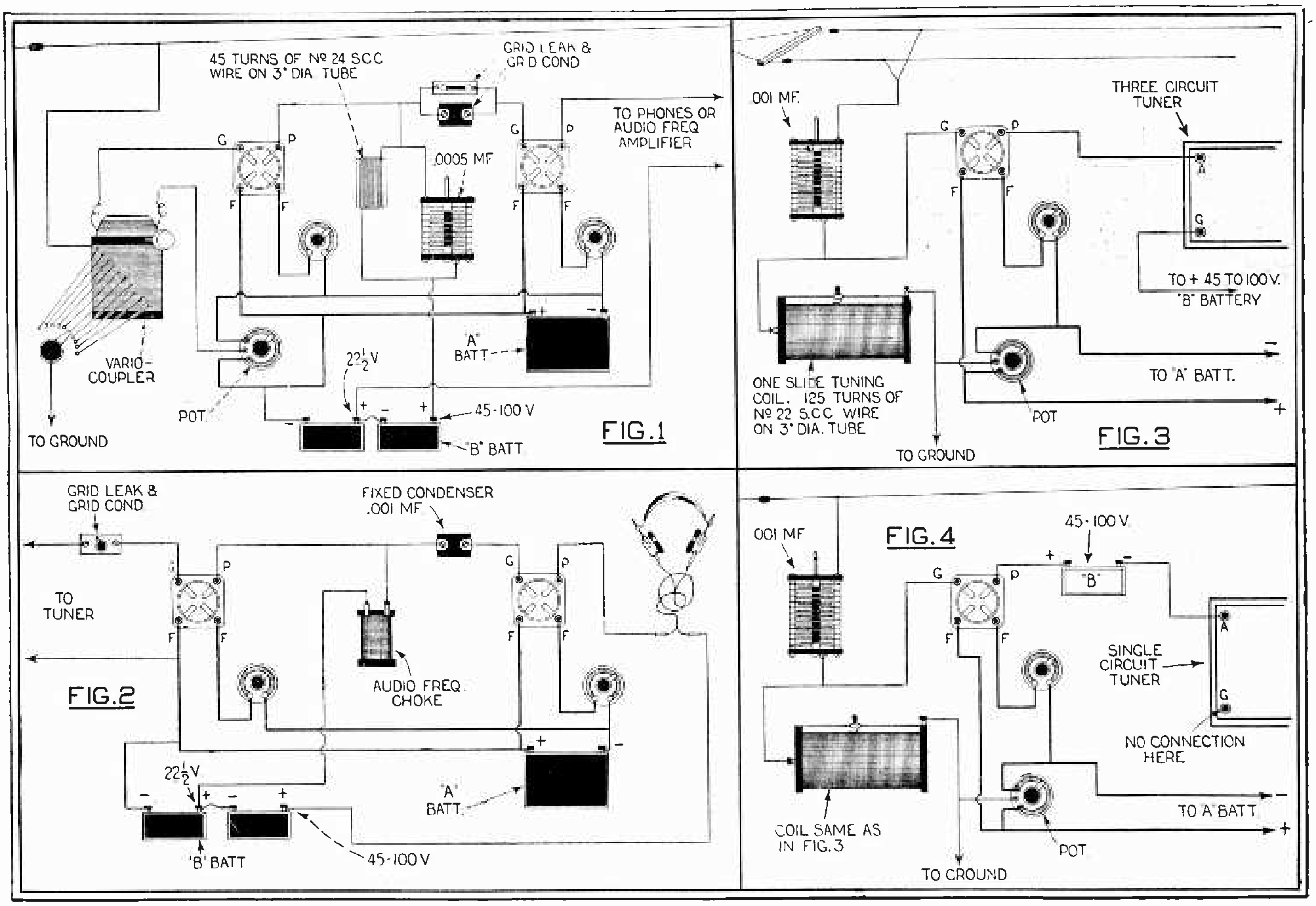


Fig. 1: An Excellent Circuit for Radio Frequency Amplification by the Tuned Impedence Method. Fig. 2: A Standard Circuit for One Stage of Audio Frequency Amplification Using an Audio Frequency Choke Coil in Place of a Transformer. Radio Frequency Amplification May Be Added to Any Three Circuit Tuner Without Changing the Interior Wiring, as Shown in Fig. 3. If a Variable Condenser Is Used in the Tuner, in Series With the Primary, It Should Be Placed in Parallel Instead, in Order to Obtain Results. A Separate "B" Battery Is Necessary When Using the Circuit Shown in Fig. 3 in Connection With a Single Circuit Tuner and the Necessary Hook-Up Is Shown in Fig. 4. No Connection Is Made to the Ground Post of the Single Circuit Tuner But the Remarks on the Variable Condenser in Connection With Fig. 3 Apply Here as Well. In Both of the Last Two Circuits, a Common "A" Battery Feeds All Tubes, and the Negative of the "B" Battery, Fig. 3, Connects To the "A" Battery.

Radio for the Beginner

XIX. AMPLIFICATION

By ARMSTRONG PERRY

THE first reaction of the thrifty soul to the irresistible alurement of radio is to purchase as inexpensive an outfit as will enable him to hear something. For a few days he thrills at the voices and melodies that respond like fairies to his touch upon the controls. Then, irritated by the necessity of snatching the phones from his head in order to share his joy with those who stand eagerly at hand, fired by the bold assertions of older fans and enterprising dealers that he can magnify those sounds 20,000, yes, a million fold, he ransacks the catalogues for the most efficient amplifier.

VACUUM TUBE BEST ALL-AROUND DETECTOR.

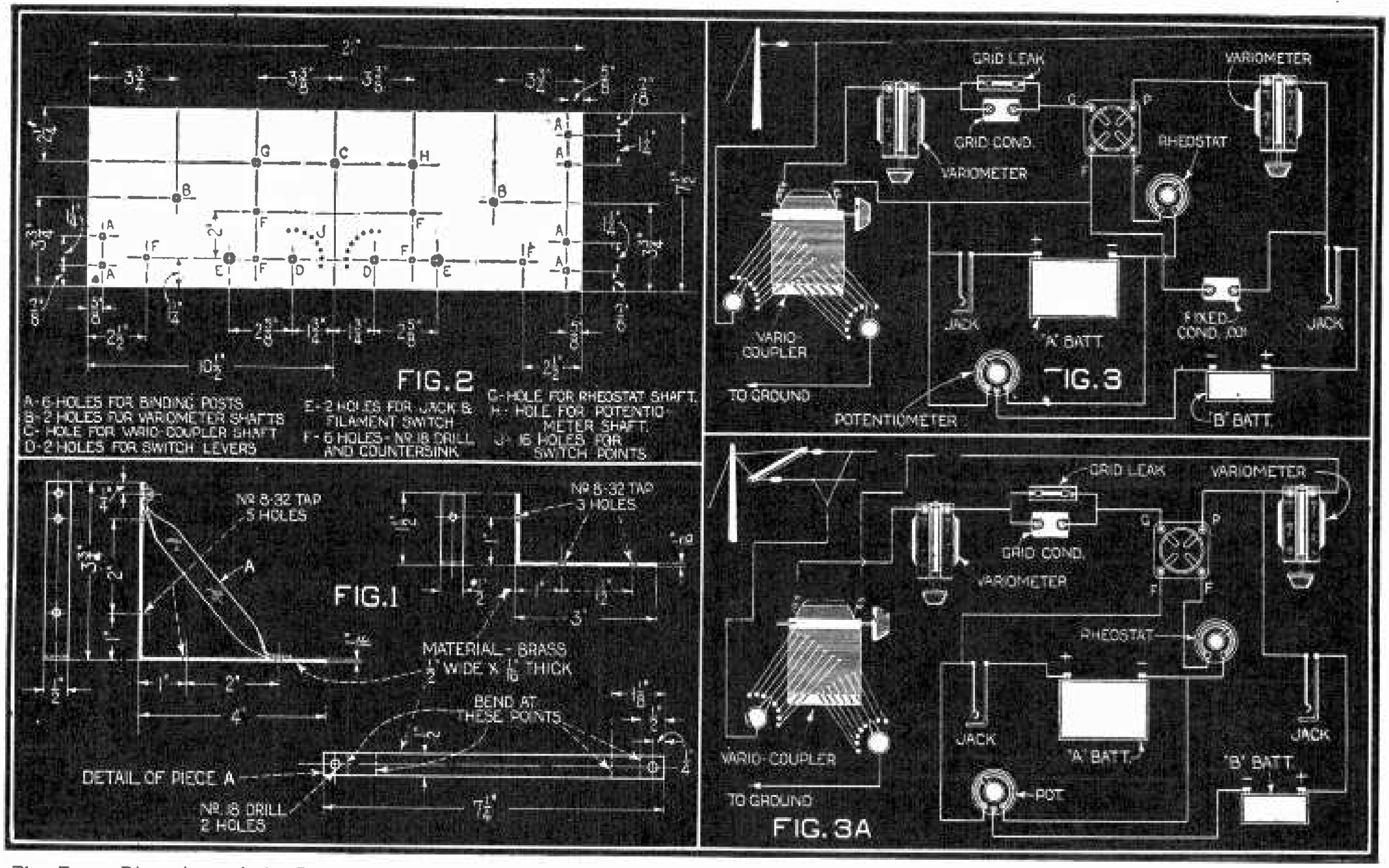
The detector tube of the single-tube set not only detects but also amplifies. The term "detector" really belongs to the 'phones rather than to the tube, which merely rectifies the oscillating currents received from the antenna, strengthens them with currents from batteries that light its filament and put pressure on its plate, and passes them on in the form of a pulsating direct current that the phones can translate into sound. The crystal detector is more successful in some respects as a rectifier of radio currents than the tube, but as it can pass on no more than it receives, the tube has the immense advantage given by the comparatively heavy currents from its "B" battery.

Grid current, in an electron tube, the current gathered by the antenna from the passing radio waves, is measured in micro-amperes or millionths of an ampere. The condenser capacities existing between condenser plates, and sometimes between parts of radio apparatus not intended to serve as condensers but nevertheless having capacity, are sometimes measured in micro-microfarads, or millionth part of millionth part of a farad. So the man who thinks he has set his dials correctly may be a million of something or other away from the adjustment that he needs for best results.

The amplifier tube can amplify only what reaches its glassed enclosure. It must amplify all the current that it receives, regardless of whether it carries songs or squeals. The first step in successful amplification, therefore, is to learn to adjust the detector bulb. A common practice is to crowd it with all the filament current it will take, making it deliver loud results regardless of distortion. The best practice is to adjust it by the finest possible gradations until it delivers only the sounds that are desired and no noises of its own making. Filament voltage and plate voltage both play a part in this, but filament voltage is usually the more critical. A rough rule is to turn on the "A" battery current until a hissing noise is heard and then turn it down until the hissing stops.

The curves that radio engineers draw to show the characteristics of electron tubes, and which beginners will do well to learn to read, explain that an increase in the grid voltage of a tube causes a much greater increase in the plate current than could be produced by increasing the voltage of the plate itself by the same amount.

Radio frequency amplification, which is being used more and more, is essentially different in that the amplification takes place before the current passes through the detector tube. A phone connected in the plate circuit of a radio frequency amplifier tube would bring to the ear no voice or music, if the amplifier is working correctly, for the modulations would be too weak to either actuate the diaphragm of the phone or make an impression on the diaphragm of the ear. The antenna current, in this case, goes to the grid of the first tube. The plate of this tube is connected with the primary of a transformer and the secondary is connected with the grid of the next tube. Sometimes, however, a different method of coupling is used, a resistance element being inserted between the plate and the positive terminal of the "B" battery, a condenser between the plate of the first and the grid of the second tube, and another resistance element between this condenser and the negative pole of the "A" battery that supplies the second tube. What is known as tuned impedance radio frequency amplification consists of an inductance coil and a condenser in parallel, connected to the plate of the first tube and the "B" battery. The plate is also connected to the next tube, through a fixed condenser.



The Exact Dimensions of the Braces Used for Supporting the Panel in This One Tube Regenerative Receiver Are Given in Fig. 1. These Give a Finished Professional Appearance to the Set. The Panel Lay-out For This Receiver is Shown Clearly in Fig. 2 With All the Necessary Dimensions Included Thereon. Fig. 3 Shows a Circuit Diagram to Be Used With This Set. and is of the Standard 3-Circuit Tuner Type. A Circuit Capable of Much Sharper Tuning in Shown in Fig. 3A, Using the Same Apparatus.

A One Tube Regenerative Receiver

By BERT T. BONAVENTURE

THERE are a great many people who would like to have a radio set in their home, but are held back by an imagined high cost for a good receiver. The following article describes a dry cell tube set, using one of the Armstrong regenerative circuits, that can be built for a nominal sum, using the standard parts available on the market.

Despite the complicated appearance of the panel, the active controls are few in number. The center dial controls the coupling between the primary and secondary circuits, while the small dial on the upper left is the vernier filament rheostat. That on the upper right is the 400 ohm plate-battery potentiometer. A filament switch is provided to turn off the dry cell when the set is not in use. Otherwise the potentiometer will always be consuming current, which although only about three thousandth of an ampere is a drain on the battery if left in the circuit continuously. The potentiometer affords a more critical adjustment of the plate-battery potential.

On the two shelves back of the panel are mounted the filament battery, with room for a spare one, and the block B battery. The tube socket and the grid condenser and leak are also mounted on the right end. In case it is desired to use external batteries, four binding posts have been provided at the left of the panel.

The construction is simple throughout, requiring a minimum number of parts to be made. A one and a half volt tube (WD-11 or other type), is used for the detector. Signals as far as 1,000 miles distant have been heard with this receiver, which costs less than twenty dollars to build, including the tube and batteries.

CONSTRUCTION OF TUNER

Both the variometers and the vario-coupler may be home-made, but it is the opinion of the writer that it is not worth the time and trouble today to make your own, as the market now affords fairly good ones at very reasonable prices. This set was made when the radio boom had just started and prices of radio apparatus were sky high. (Some of the parts have been replaced by more recent apparatus.) For the benefit of those who would like to try their hand at constructing the tuning units, the table below will furnish the necessary data.

DATA ON TUNING ELEMENTS

	Instrument	No. of Turns	Size of Wire	Mean Diameter
Plate Variometer	Rotor	82	No. 22 D.C.C.	3½"
	Stator	76	No. 22 D.C.C.	3½"
Grid Variometer	Rotor	64	No. 20 D.C.C.	3½"
	Stator	60	No. 20 D.C.C.	3½"
Vario-coupler	Primary	56	No. 18 D.C.C.	4½"
	Secondary	30	No. 18 D.C.C.	3½"

HOW TO WIRE THE SET

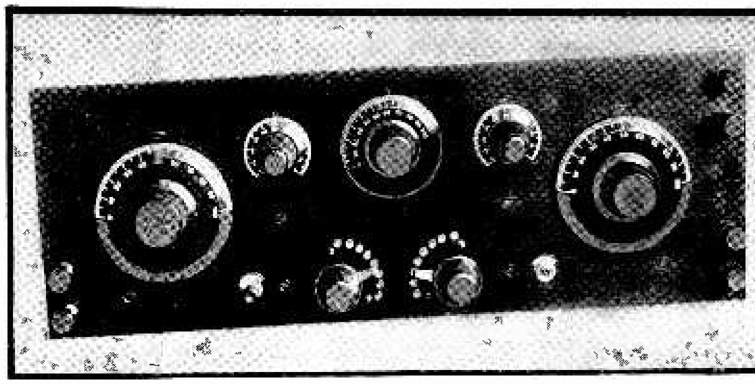
There is very little explanation necessary regarding the construction of the set, as the photos and figures practically tell the story. The shelves are held to the panel by means of two brackets on each shelf, as shown in Fig. 1. The brackets themselves are held to the shelf by two 8/32 flat head machine screws through the bottom of the shelf, countersinking the holes so that the heads of the screws will not protrude. Several methods of holding the batteries in place may be used, but a narrow leather strap around the battery will do very nicely. The ends of the strap are held by wood screws with washers under the heads.

A word about the wiring will not be amiss. Experience teaches that the low voltage leads of the set need not be wired with bus bar wire, such as the leads from the A and B batteries. Hence these circuits have been wired with twisted pairs of lamp cord to reduce the labor of wiring. Small brass staples may be used to hold the wire in position on the sub-base, or two small holes may be drilled where it is desired to hold the wire down, and the wire may be tied in place with thin twine or cord. No iron of any sort should be used in the construction. Only the high voltage parts of the circuits have been wired with bus bar wire, such as the grid and plate circuits. The wiring circuits are shown in Fig. 3. Two possible circuits are shown, with the preference to Fig. 3A, as the oscillations of the circuit may be more easily controlled. Fig. 3 is a standard Armstrong three circuit tuner.

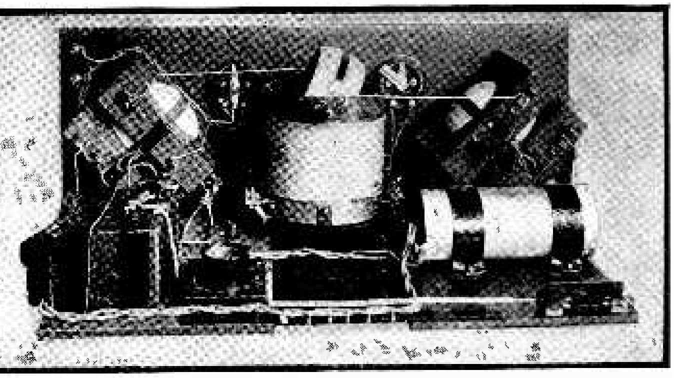
MATERIAL NECESSARY

To build the set, the following parts should be used:

1 Bakelite panel, 7½" x 21" x 3-16"
2 Variometers.
1 Vario-coupler
1 Set of switches and contact points for units and multiple taps.
1 Vacuum tube socket.
1 ½-Volt tube (W. D. 11 or other type).
1 Vernier rheostat.
1 400 Ohm potentiometer
1 Filament switch (built on the style of a jack and mounted in the same manner)
1 Single circuit jack.



The Two Photographs Above Show the Front and Rear Views of the Extremely Efficient Single Tube Radio Receiving Set Described in the Text



By Using a Little Care in Laying Out the Set, it is Possible to Produce a Very Finished Instrument.

1 Grid condenser, 0.00025 Mfd.
1 2 Megohm grid leak.
1 Phone condenser 0.001 Mfd.
2-4" dials.
1-3" dial.
1-2" dial to match rheostat dial (goes on potentiometer shaft)
6 Binding posts
1 "B" battery, 22½ V.
1 Dry cell
2 Pieces of wood for sub-base and shelf 11" x 7" x ¼"
4 Brass angles as per Fig. 1
Leather strapping.

Fig. 2 shows the layout of the panel, giving the center lines of the holes to be drilled for the shafts of the various instruments. No attempt has been made to give the dimensions of the mounting holes, as these will vary with the type of apparatus used. The heads of the six 8/32 flat head machine screws, which hold the brass brackets against the panel, were lacquered in dull black to render them less conspicuous. A brass strip has been fastened at the rear of the sub-bases to give added rigidity and prevent a possible sideplay in the shelves. The photograph of the rear of the set shows this strip clearly.

If the builder does not like an arrangement that runs as deep into the rear of the panel, the self-contained A and B batteries may be omitted and the binding posts used. It is convenient, however, to have everything in the cabinet.

OPERATING THE SET

As to operating the receiver, the primary circuit is first tuned by means of the units and multiple switch taps, following up this operation with the tuning of the grid and plate circuits by means of the two variometers. Tune with a hand on each variometer dial, following the grid tuning with the plate variometer. Quite precise tuning can be accomplished with the coupling control after the plate and grid variometers have been set for a given signal; the method should be in more general use.

New Vacuum Tube With Nine Lives

A NEW model Radiotron tube known as the UV-199 has recently been put on the market and become an instantaneous success. A new tungsten filament has been placed in this tube which consumes only .06 ampere at 4½ volts. The total wattage consumed is only 1/27th of the amount used in the UV-201 tube, but the new audion has characteristics which render it better for use in a radio set than the old type of tube. With 80 volts on the plate and a negative bias battery, the watts drawn from the "B" battery are slightly greater than the watts drawn from the "A" battery.

Due to extremely low current consumption of this new tube it can be very economically run on ordinary three cell flashlight batteries. In fact, No. 6 dry cells will last for about a year when used with this tube under ordinary circumstances and usage.

AN EXCELLENT RADIO FREQUENCY AMPLIFIER

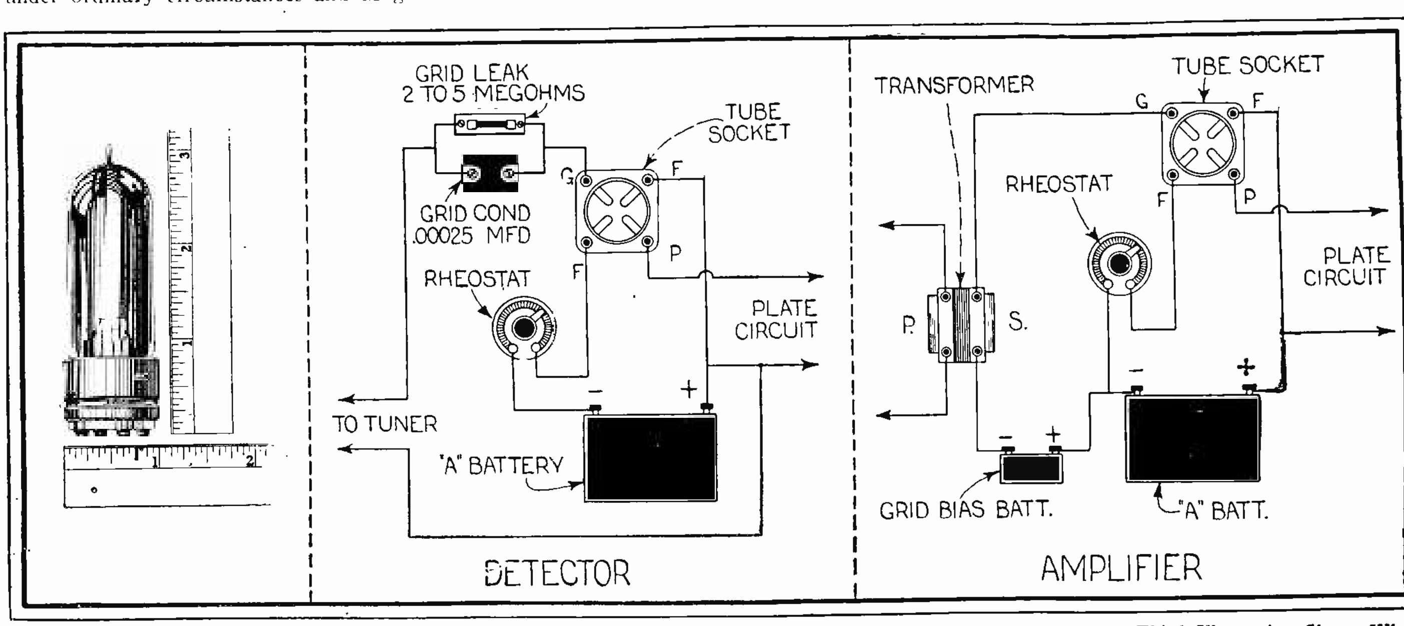
This new tube can very well be used in radio frequency amplifiers where it gives exceptional results due to the fact that its internal capacity is very low.

It is practically impossible to burn out this tube because when too much current is supplied to the filament, the electronic emission automatically falls off and the tube becomes inoperative. In order to bring it back to a normal state it is necessary to burn the filament of the tube for some time without any plate battery connected in the circuit. The length of time required for recuperation is dependent upon the length of time at which the tube was operated at abnormal voltage.

When interference and static are at a minimum the grid leak should have a value of from six to ten megohms. However, with severe QRM or static the leak should have a resistance of about two megohms. In general a five megohm leak will give very satisfactory results under all conditions.

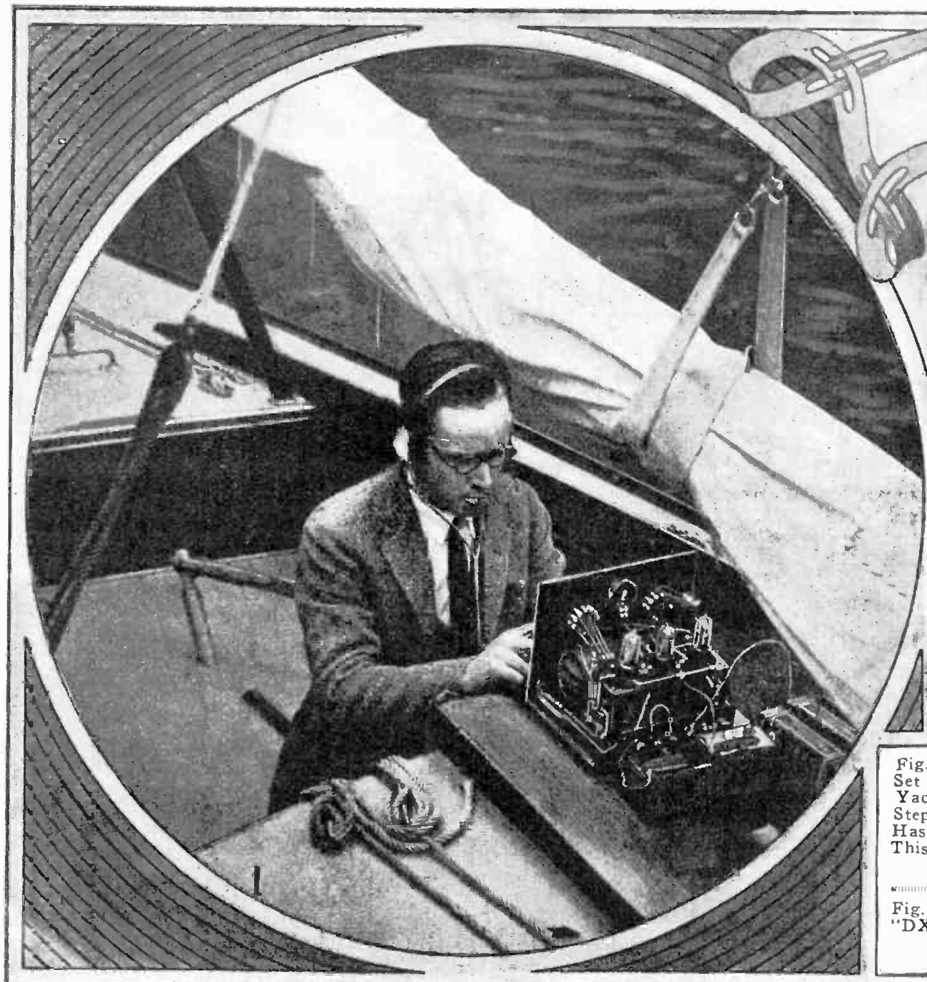
GRID BIAS NECESSARY

When these new tubes are used as amplifiers it is quite necessary that a grid bias battery be used. This should be inserted in the transformer to filament lead and should have the negative side connected to the transformer. The following values will be found to give good results for various voltages on the plate. With 40 volts on the plate use from .5 to 1 volt grid bias, for 60 volts, 1 to 3 volts bias, and for a plate voltage of 80 use 3 to 4.5 volts between the filament and the transformer.



At the Left Will Be Seen the U. V.-199 in Comparison With Two Standard Rulers. Its Small Size Can Be Readily Seen. The Second Illustration Shows How the Connections to the Filament Circuit Should Be Made When the Tube is Used as a Detector, While the Third Illustration Shows What Changes Should Be Made in This Circuit When the Tube is Used as an Amplifier. These Connections are Quite Important.

PORTABLE "DX" RECEIVER



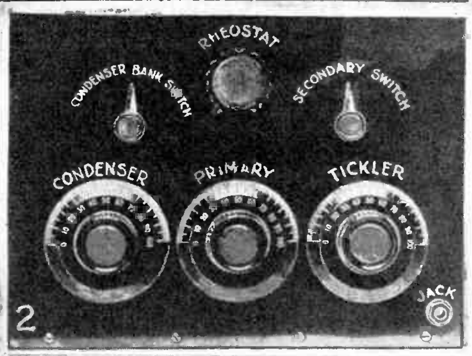
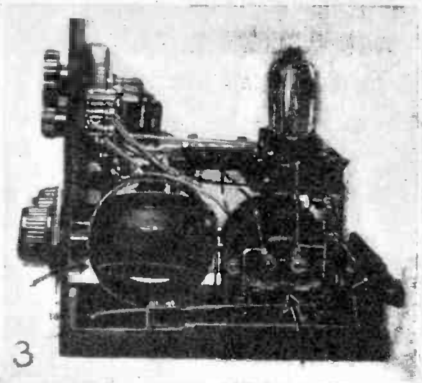
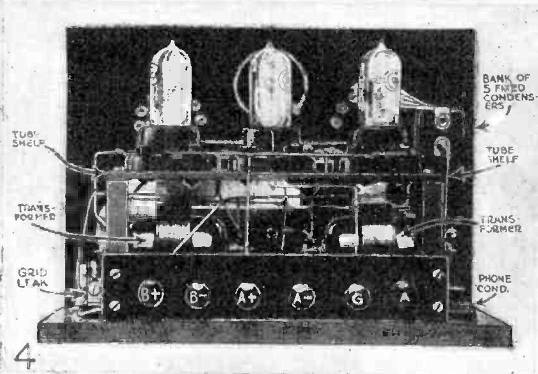


Fig. 1 At Left Shows the Portable Vacation Radio Set Described by Mr. Price in Use on a Pleasure Yacht. This Set Comprises a Detector and Two Step Audio Frequency Amplifier. This Receiving Set Has Been Designed and Tried Out by Experts and This Article Will, Therefore, Be of Unusual Value and Interest to All of Our Radio Readers.

Fig. 2 Above Shows Front Panel View of the Portable "DX" Receiver. The Controls for Tuning Are Simple, Considering the Fine Selectivity Possible.





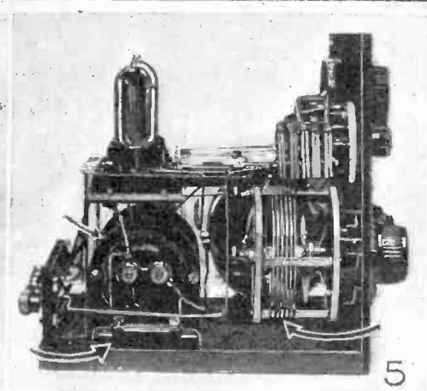


Fig. 3 at Left Shows the View From the Right Side or Tickler End of the Portable "DX" Receiving Set. It is a Good Idea to Mount the Vacuum Tube Sockets on a Shelf or Frame Supported on Sponge Rubber or Else on Rubber Bands, to Absorb Any Vibration or Jars; Especially if the Set Is to Be Carried on a Boat or Automobile. Fig. 4 Above Shows the Rear View of the Portable "DX" Set, While Fig. 5 at the Extreme Right Shows a View From the Left or Condenser Side of the Outfit.

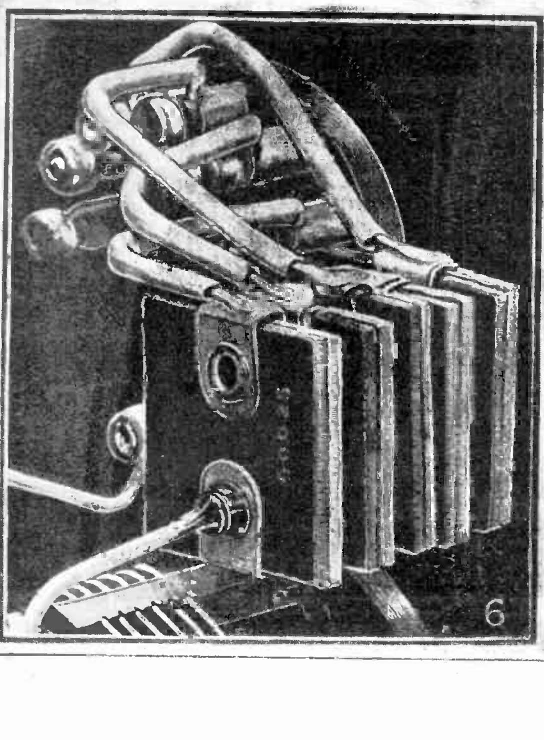
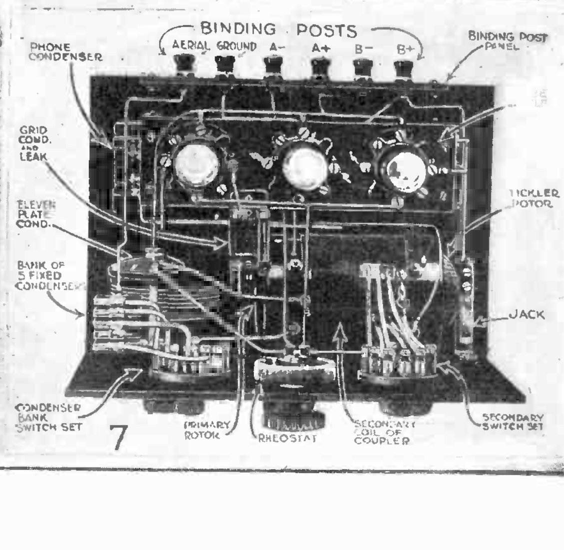


Fig. 6, at Left, Shows the Bank of Small Mica Condensers Used in Series with the Antenna in the Place of the Usual Variable Condenser. This Bank of Condensers May Be Substituted by a Variable Condenser if Desired, However, as the Author Points Out. A Switch Enables the Operator to Connect in as Many of These Condensers as Necessary.

Fig. 7 at Right Shows a Top View of the "DX" Portable Receiving Set.



A DX Portable Receiver With Novel Tuner

By P. A. PRICE

A VACATION dry battery radio tube set that is easy to make, simple to operate and highly efficient—one, of course, that will work equally well at home—has been evolved for the benefit of the radio fans after a long series of tests to determine just what type of set would "deliver the goods" on the vacation and at the same time be within easy reach of Mr. Radio Fan's pocketbook.

Here is a set which can be used in camp, on auto trips, on motor boats or yachting cruises, at the summer home or back home on the old front porch or in the parlor for the stay-at-homes. It has a summer range of 1,000 to 1,500 miles and under ordinary favorable conditions has received California stations at Cleveland, Ohio. Its range for loud speaker use in summer is around 300 miles and most radio fans on their summer outings will be within easy range of broadcasting stations.

NOT A FREAK, JUST A REGULAR SET

This vacation set is not a freak. The circuit used, an ordinary three-circuit hook-up, is tried and tested. It makes use of a primary-secondary-tickler coupler consisting of a secondary stator coil at both ends of which are rotors for the primary and tickler coils. A detailed description of this coupler is given in succeeding paragraphs. The circuit has been used most successfully by amateurs and others and during the test of the model set. Detroit and other stations were tuned in through WJAX, the powerful station of the Union Trust Co., of Cleveland, Ohio.

The detector and two-stage amplifier are mounted on a panel 8x11 inches, the base being 11x7½ inches and ½ inch thick, making it most compact and handy to stow away as luggage. It may be fitted with a box-like cover and a handle attached for convenience in carrying.

The batteries, of course, are not contained in the set. For vacation use they may be carried along in a separate box, providing tubes using dry cells are utilized. The test set contains three UV-199 tubes, which are connected in parallel and controlled by one 10-ohm rheostat. Three dry cells, connected in series, are used to supply the 4½ volts required for these tubes. It is well to remember that a 25 or 30 ohm rheostat is required for UV-199 tubes when these tubes are used singly on a dry cell battery, and that a 60-ohm rheostat is required when a 6-volt storage battery is used for individual tubes.

Of course if standard 6 volt tubes are used, a 6 volt A battery will be required. With the WD-11 and WD-12 tubes 1½ volt dry cells will be required for the A batteries. In all cases the B battery voltage remains at 45 volts, although 22½ volts may be applied to the detector tube if found best.

The recommended aerial for use with this set is a single wire 100 feet long. For an inside aerial it is recommended to use **two,** three, or four wires, each as long as possible up to 75 feet, the wires being connected at one end and being left free at the other, the lead-in being attached to the end-connecting wire.

For use in camps a single wire aerial 100 feet long can be strung up between trees, as high as convenient. On a motor trip, the 100 foot single wire aerial may be thrown over a tree branch and attached to the set in the auto, the aerial being properly insulated where it touches the tree. It is not practicable to try to use the set in the car while traveling, although by rigging up a proper aerial and ground this might be done.

If it is desired to use the set on a motor boat or on a yachting trip, an aerial strung from one end of the boat to the other may be used, any metal part of the boat which touches the water being used for ground.

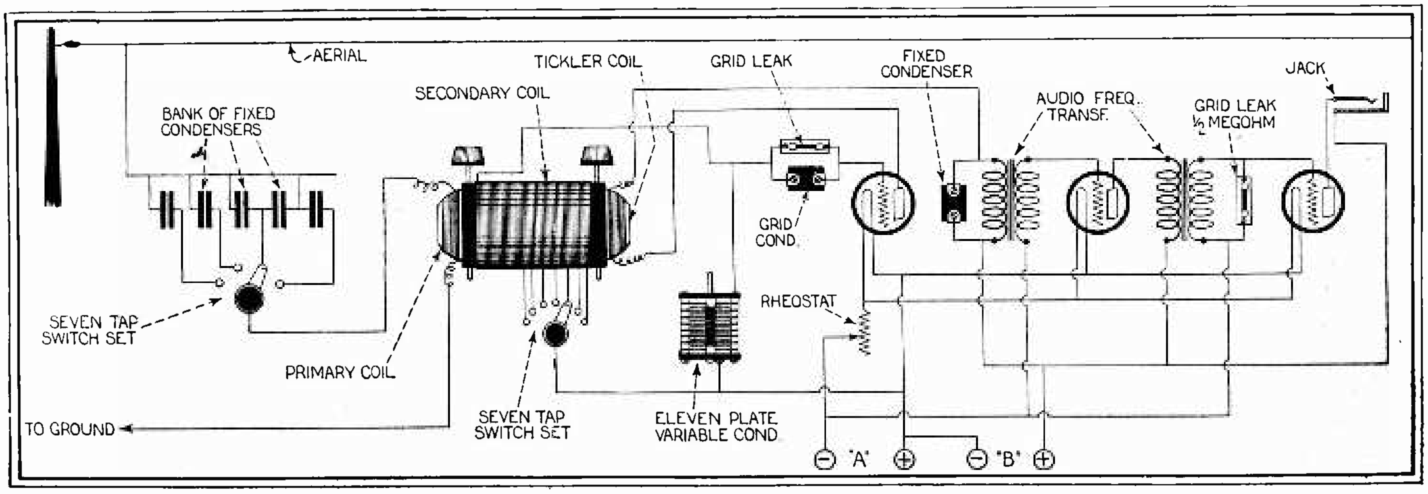
ALL UNNECESSARY PARTS ELIMINATED

In submitting this circuit for the use of radio fans all unnecessary parts have been eliminated. The three vacuum tubes are operated from one rheostat, so that the two stages of amplification are always in use when the set is being operated. The test set was made of the highest grade parts obtainable and thus constructed, the parts, without tubes, phones or batteries, should not cost more than $45.00 or $46.00. With tubes, phones, and batteries the cost should be around $77.00. This, of course, is exclusive of labor.

It is not necessary to use the same parts as described in the test set. Cheaper parts may be used or parts taken from other sets. The only part described and which is necessary to retain is the P-S-T (or primary-secondary-tickler) coupler, and this coupler may be constructed by the radio fan.

The coupler consists of a bakelite tube 4¾ inches long, having a 3-inch diameter. This forms the stator or secondary coupler and upon it are wound 75 turns (60 feet) of No. 21 or 22 silk-covered wire. Taps are taken out at the 40th, 50th, 60th, and 70th turns, on the tickler end of the winding. The winding starts about 1¼ inches from the primary end. The 40-turn tap is for 200 meter work. If broadcasting only is desired no taps need be provided and the entire coil is used.

(*Continued on page* 489)



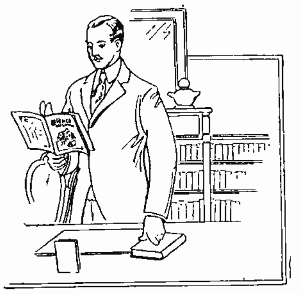
The Specially Designed Receiving Set Fully Described and Illustrated Herewith Will Prove of Exceptional Interest To All of Our Readers, For the Reason That It Has Been Fully Tried Out and Has Been Featured In the Radio Department of One of the Leading American Newspapers. It Is Unusually Selective, and Distant Stations Can Be Heard Even When Nearby Broadcast Stations Are Operating. One of the Novel Features Lies In the Special Tuner Or Compound Variocoupler Which Has a Fixed Secondary, With Rotary Primary and Tickler Coils.

Pitfalls of the Radio Inventor

By EVERETT N. CURTIS

(DON'T FAIL TO READ THIS VALUABLE ADVICE ON PATENTS)

MANY engaged in research and experimental work, often victims of their own lack of knowledge, or of inertia, unwilling or unable to acquaint themselves with well known principles underlying the patent law, are prone, when finding themselves in a disagreeable situation into which their ignorance has led them, to blame the law or some person who they think has taken advantage of their necessities and has caused them to lose valuable patent rights. The purpose of this article is to point out some of the pitfalls into which the inventor falls, for his descent into which he himself through ignorance is mainly to blame, and to indicate ways and means by which such errors may be avoided.



Publishing an Idea in a Magazine Gives You Protection for a Period of Two Years. You Should Apply for a Patent Within This Time, or Else Patent Proceedings Are Not Possible.

RECORDS ARE IMPORTANT

Generally speaking the inventor is woefully unaware of the importance of keeping records and drawings of his invention and of preserving evidence of the earliest date thereof, the dates of disclosures to others, and the dates of reduction to practice. He is ignorant of the bearing which the prior art or prior knowledge and use or the prior years statutory bar or abandonment of his invention, has upon his rights before he applies for a patent. He is ignorant of the effect of many years of concealed use of his invention such as for example, a secret process. He is ignorant of the effect of filing an application without a full disclosure of his invention and without adequate claims covering its full scope. He is ignorant of the requirement that all applications for patent in this country must be filed by the inventor, and that the filing by joint inventors, (so-called) is in many cases a snare and a delusion and likely to result in the patent being declared void. He is ignorant of the necessity of guarding against the disclosure of his invention to the world by the issuance of the patent in this country, until he has protected his right by filing in foreign countries. He is ignorant of his rights when he makes an invention while employed by others, where such invention is in the same line of work as that of his employment. He is ignorant of the effect of licenses and assignments, and the duty imposed by law of recording assignments at the Patent Office at Washington. He is ignorant of the fact that in any event all he obtains from a patent is the right to exclude others from the patent domain if his patent proves valid in the courts, and a right of recovery for his damages or the infringer's profits.

This enumeration may seem at first glance as embracing matters technical in character, such as only to he apprehended by a patent lawyer of mature judgment and experience. The fact is, however, that any person of average intelligence may with little application, acquaint himself with the law sufficiently to safeguard his inventions to some extent and to avoid litigation which might otherwise ensue.

Mr. Everett N. Curtis, the author of this article is the lecturer on patent and trade-mark law at Columbia University and is patent solicitor in active practice in New York City. He is the author of Curtis's Manual of the Sherman Law and of a number of monographs. He was graduated from Massachusetts Institute of Technology in 1898, and from the Boston University Law School in 1900.

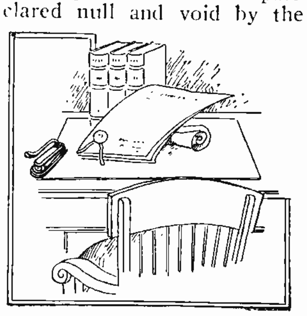
PATENT LAW IS OLD

The patent law in this country is derived from the English law as it existed at the time of the colonies. Under our constitution it is provided that the Congress shall have power to promote the progress of science and useful arts by securing for limited times to inventors the exclusive right to their discoveries. The word "discoveries" is unfortunate, but is interpreted by the courts to mean the same thing as inventions. Beginning in 1790, a number of patent acts have been passed by Congress, and the law has become finally crystallized in the Acts of 1870 and 1875 as amended to date.

The most important provision of the law is Section 4886, under which it is provided, among other matters, that any person who has invented any new and useful art, machine, manufacture, or composition of matter, or improvement thereon, not known or used by others in this country before his invention or discovery thereof, may obtain a patent. Thus it is provided that in every application for patent there must be present invention, or exercise of the creative faculty; there must be present novelty or newness; and there must be present utility, or usefulness. It is also provided in effect in the same section that a publication, either here or abroad, *two years prior to the filing of the application or a two years public use or sale in this country prior to the filing of the application, will preclude the issuance of the patent thereon.* Accordingly underlying the validity of any patent, are the prerequisites of invention, novelty and utility and the so-called statutory bars. Even though the patent be issued, no defendant is precluded from showing that such patent is defective in any one or more of these particulars and accordingly void.

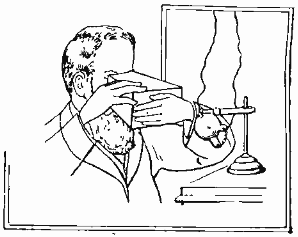
THE RIGHTS A PATENT GIVES TO THE INVENTOR

All that the inventor secures by his patent is the right, in the first instance, to exclude all persons from making, using or selling the inventions covered by it. This, it is true is a very substantial right and includes not only the right to an injunction but also the right to damages and profits. It should be borne in mind, however, that this right is negative in character and is only presumptive, and that a patent may be declared null and void by the courts for a variety of reasons, as for example, that the inventor was not the true inventor, that the so-called invention is not an invention but involves only mechanical skill, that it is not new, or that it will not operate, etc.



Protect All of Your Early Drawings and Notes by Having a Notary Sign and Seal the Papers. Or Draw a Sketch With a Description and Mail it to Yourself.

All inventions must be regarded in the light of the prior state of the art, and measured by the advance which they have made. If they are basic in character and perform a function never before performed, they are termed "primary" or "pioneer" inventions, such as the Goodyear process for vulcanizing rubber, the Morse telegraph, or the Bell telephone, and are construed broadly. If they are improvements upon what has gone before, they are secondary inventions and are narrowly construed. Mere mechanical skill is not invention, neither is mere aggregation, nor doubling of an old structure, nor duplication, nor enlargement, nor mere change of form.



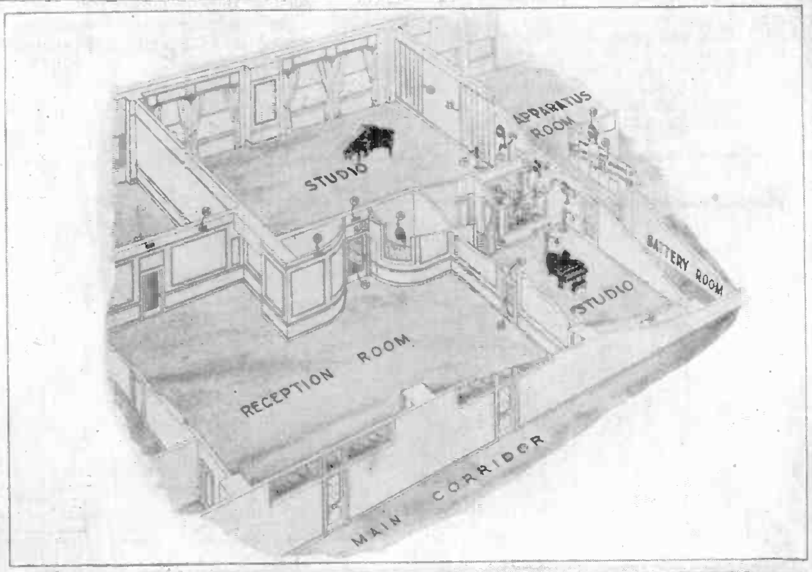
The X-Ray as Discovered by Roentgen Was a Truly Basic Invention. While More of a Discovery Than an Invention, It Involved a Basic Fact.

Want of novelty may be shown by prior publications or patents in any language or by any prior knowledge or use accessible to the public. Want of utility may be proved by showing that the so-called invention is inoperative, or that it is injurious to the morals, health or good order of society.

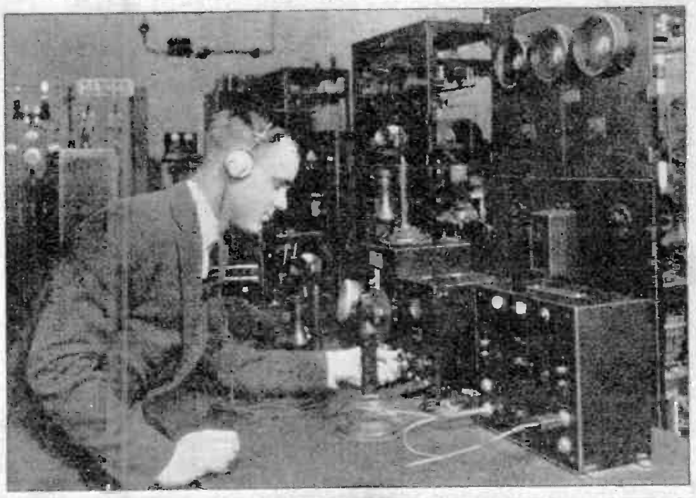
One of the first steps to be pursued by an inventor should be to ascertain whether or not his invention is new, that is if it has patentable novelty. If he is a skilled mechanic, or if he is engaged in a business which brings him into close contact with the art and the trade, he will probably know if there is any commercial device at the time on the market which anticipates his invention. But this tells him little. It is possible that there may be somewhere in the world a prior printed publication accessible to the public showing and describing his device which he has not seen. If there is any such publication, it is probable that there is a copy of the same in the U. S. Patent Office, or perhaps in some public library in any of the great cities. A search therefore at the Patent Office and through technical libraries accessible to the public would probably disclose the publication. In order, however, to be fairly certain there were no prior publications, a very thorough search would be required, which would be expensive and perhaps beyond the means of the ordinary inventor, who would have to be satisfied with his own investigation at a public library, where both scientific works and copies of domestic and foreign patents might be accessible, or he might have made for him the usual preliminary examination by some resident patent attorney at Washington, who for a small fee would make a cursory examination of the class of U. S. patents where the invention was likely to be found and would send copies of the nearest patents. Such preliminary examination is often of great advantage, since it will usually disclose any very close references; but the inventor must be cautioned from placing too much dependence upon it, as it is at best only a makeshift and cannot in the nature of things be exhaustive.

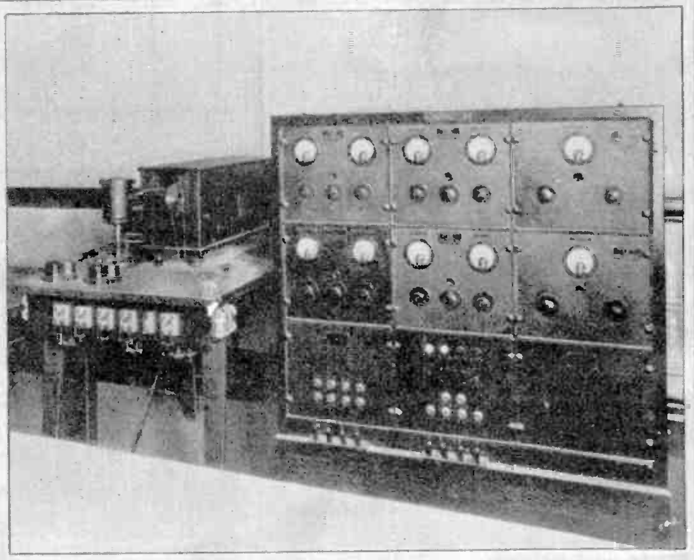
(To Be Continued.)

BROADCAST-STATIONS

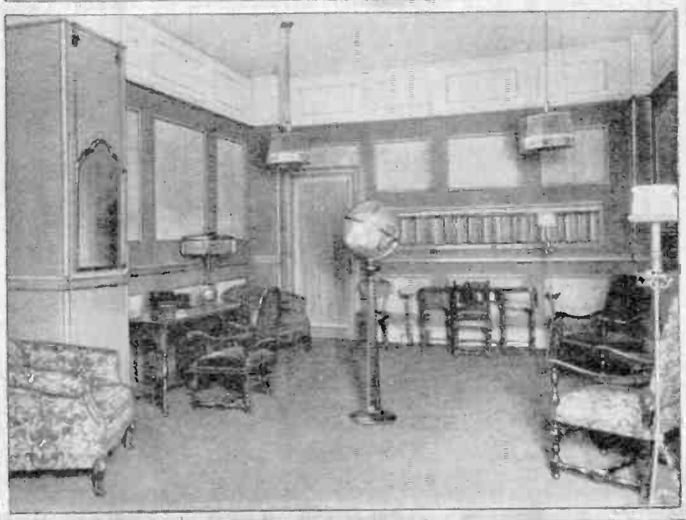


The Photograph At the Left Gives a Comprehensive View of the Aerial and Masts of Station WEAF, of the American Telephone and Telegraph Co., New York City. The Antenna Is Located On the Walker Street Building, and the Studio, a Prospective View of Which Is Shown Above, Is Located At 195 Broadway.





Above: The Operator of Broadcast Central, Controlling Stations WJZ and WJY, New York City. At Right: The Visual "Check Up" Device Which Gives A Sight Record of All Transmission From These Two Stations.



At Left: Studio of WJZ From Which Classical Selections Are Broadcast. Above: Jazz Studio of WJY.

Radio Oracle

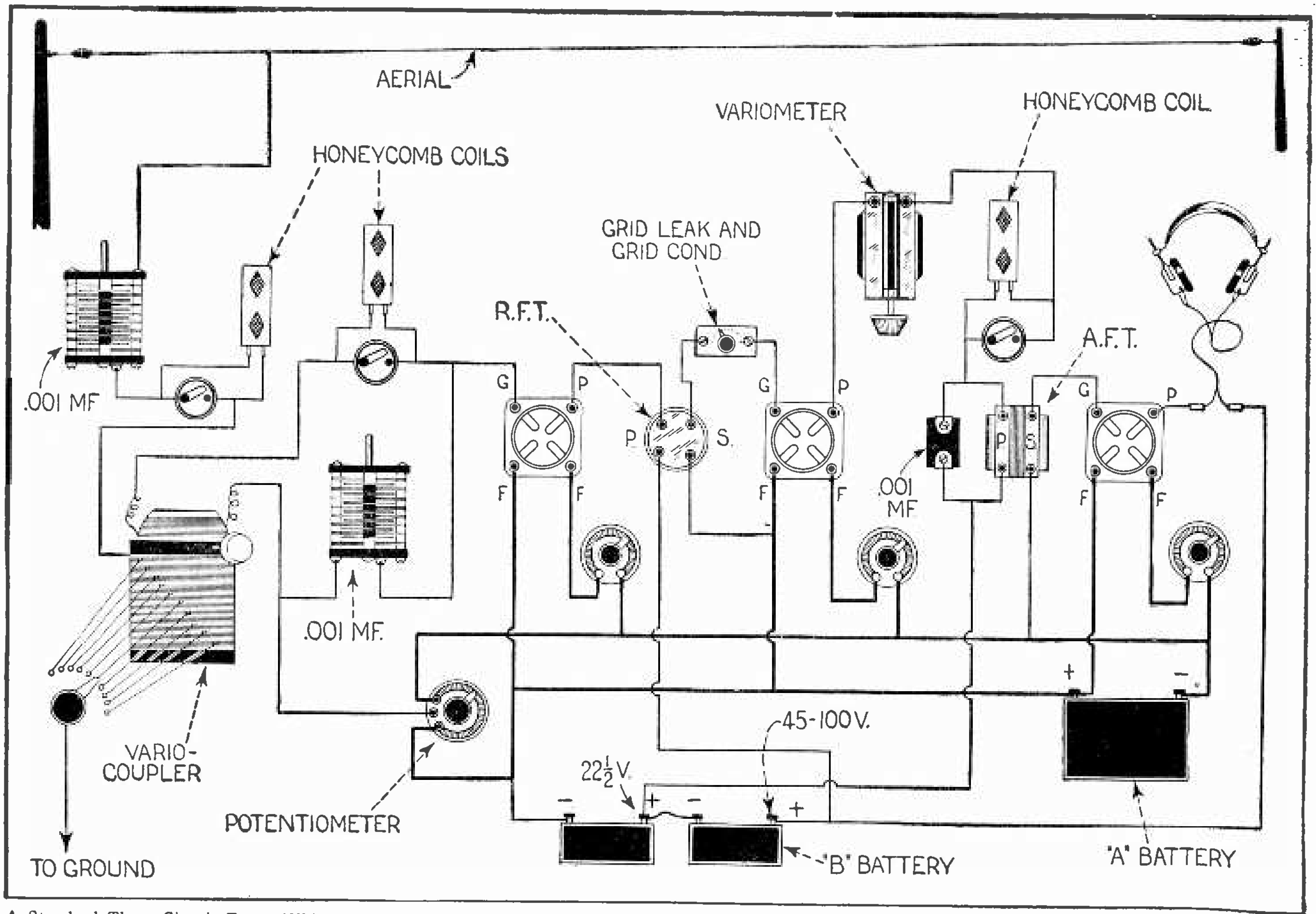
In this Department we publish questions and answers which we feel are of interest to the novice and amateur. Letters addressed to this Department cannot be answered free. A charge of 25c is made for all questions where a personal answer is desired.

LONG AND SHORT WAVE TUNER

(173) Edward Freyer, Holyoke, Mass., requests:

Q. 1. Can you give me a circuit diagram of my present three-circuit tuner which employs a vario-coupler and two variometers with the necessary additions to change over by means of switches to a three-coil honeycomb tuner? I also wish to change my present two-step amplifier to one step of radio frequency amplification and one step of audio frequency amplification. Kindly indicate this in the diagram.

A. 1. You will find the required circuit diagram given in these columns.



A Standard Three Circuit Tuner Which May Be Used For Receiving Either Short or Long Waves, With One Stage of Radio Frequency Amplification. The Radio Frequency Transformer Must Be of a Type That Will Cover the Band of Wave-Lengths Over Which the Operator Desires the Set To Receive.

110 VOLT AUDIONS

(174) W. F. J. Fischer, Texarkana, Ark.-Tex., asks:

Q. 1. How can I use two burned-out and one new 110-volt electric light bulbs as audion tubes, and how can a four-cell aluminum and lead rectifier be used in the head-set circuit?

A. 1. You cannot use 110-volt electric light bulbs in place of audions in a radio receiving set, nor can you use a 4-cell rectifier in the phone circuit. Allow us to suggest that you purchase some one of the many text-books on radio on the market today, and study them so as to get a better insight into the workings of a radio receiving set.

RADIO ENGINEERING

(175) A. Egli, Lima, Ohio, says that he is a High School graduate, and desires taking up radio engineering. He asks:

Q. 1. Is there a good field open in this work, which would furnish sufficient compensation to make up for any study which will be necessary?

A. 1. A short course in Radio engineering will undoubtedly enable a graduate to secure employment. There is not much danger that the field will be over-supplied by correspondence schools more than it is now.

Undoubtedly, the field will be as great as the telephony field; but the position the individual secures will depend entirely on his own initiative and to what extent he specializes in this work after entering it.

If a man 33 years of age is ardently desirous of getting into a really good position, and intends to study from now until he has reached the pinnacle of his career, it is advisable to enter into the Radio field. Best of all would be apprenticing yourself to a Radio-technician or acting as an assistant in a radio research laboratory.

AMPLIFIER TROUBLE

(176) E. C. Fenske, Nanuet, New York, sends us circuit diagram of his set and says that his detector works fine, but gets very little amplification on his second and third tubes. He asks:

Q. 1. Is my circuit diagram correct and if so can you give me any assistance in this matter?

A. 1. There is nothing wrong with your hook-up whatsoever, and if you are unable to obtain good results with your set, we would say that the trouble is with some of the instruments. The only change we would make in your circuit is to shunt a small fixed condenser across the first jack.

It is entirely possible that one or both of your transformers may be either short-circuited, or else may have an open circuit in them. It may also be that your amplifier tubes are not getting the correct filament and plate voltage for their particular characteristics.

We would also suggest that you remove all the tubes from their sockets and clean the ends on the prongs, as well as the brass springs which make contact with the bottom of the tubes, and that you connect the filament side of your secondary to the positive side of the filament, rather than to the negative. This will produce better results

It is within the realm of possibility that you do not have your set connected up exactly as shown in the diagram, or it may be that your connections are not soldered tightly. Whenever you solder a connection, you should always test it by pulling lightly on the wire to see whether or not it will separate from the part to which it is soldered. If it will separate with a slight tug, you may be sure that it was not making a perfect electrical connection.

VARIOMETERS WOUND INCORRECTLY

(177) Edwin Converse, Pioneer, Ohio, submits a standard three-circuit tuner diagram and states that his variometers are wound with 74 turns on the stator and 58 turns on the rotor. He says that he is unable to get good results with this circuit and asks:

Q. 1. How can I make this circuit work correctly?

A. 1. Providing that all of the connections shown in your circuit diagram are correct, we do not see any reason at all why your set should not work with the exception that your variometers are not wound correctly. We would advise you to reduce the number of turns on the stator coils to 56, so that the two coils balance better.

A small fixed condenser shunted across the phones will generally give better results and we would advise you to employ the same.

MORE TROUBLE

(178) Mr. Robert Brandon, Grand Rapids, Mich., says that he has hooked up a set using a loose coupler and an audion detector, but is unable to get any results whatsoever, he asks:

Q. 1. Can you tell me why my set fails to operate and give me some pointers on the same?

A. 1. The reason you do not hear anything with you audion detector set might be any one reason of many. For instance, your "B" battery and filament currents may not be adjusted correctly, or your batteries may not be strong enough. Also, be sure that the polarity of your "B" battery is correct. The positive pole must be connected to the plate.

Regarding this set, we would say that you should go over all your connections carefully and solder all those that are not clamped tight in binding posts. Also, be sure that your loose coupler is in good shape, and that the fine wire on the bobbins of your receivers is not broken. Aso, try adjusting your grid leak.

When you do get signals, a variable condenser, shunted across the secondary of your loose coupler will give much finer tuning.

BATTERY CONNECTIONS

(179) F. O. Grams, Genoa, Ill., mentions a diagram appearing in this magazine in which the negative of the "B" battery is connected to the positive of the "A" battery. He says that he has used this connection several times and could not receive anything until he connected the negative of the "B" to the negative of the "A." He asks:

Q. 1. Is not the connection you show a mistake?

A. 1. While it is true that some tubes work best with the negative of the "B" battery, connected to the negative of the "A" battery, still other tubes will work best with the negative of the "B" connected to the positive of the "A". It is always best in hooking up a set to try both connections to determine which one is best.

The writer personally has a tube which will work equally well with either connection. Therefore, we do not consider that the point which you brought up is an error.

LONG WAVE RECEIVER

(180) A. J. Guertin, Amsterdam, N. Y., asks:

Q. 1. What instruments would you recommend for a receivnig set which will tune from 200 to 23,000 meters, using one stage of radio frequency amplification and two of audio frequency amplification?

A. 1. In order to tune from 200 to 23,000 meters, it will be necessary to use honeycomb coils for tuning. We give below a diagram showing how to connect one step of radio frequency, a detector and two steps of audio frequency amplification to three honeycombs, used as primary, secondary and tickler. The first, third and fourth tubes are amplifiers, and the second is a detector. The first transformer is of radio frequency type, and the second and third are of audio frequency types An "A" battery potentiometer is necessary for the correct operation of this circuit. A small fixed condenser with a capacity of about .001 mf. should be connected across the primary of the first audio frequency amplifying transformer. Two .001 mf. variable condensers are used, one shunted across the secondary, and one in series with the primary honeycomb coils. The "B" battery must be so arranged that 22½ volts or slightly more or less, may be applied to the detector tube, and from 45 to 100 to the amplifying tubes A single 6-volt storage battery may be used for lighting the filaments in this circuit, providing it is of sufficient capacity.

RADIO FREQUENCY TROUBLE

(181) Eugene Fouch, Brooklyn, N. Y., refers to a particular radio receiving outfit employing radio frequency amplification and says that he is unable to get any results when his radio frequency amplification is connected. He asks:

Q. 1. Can you give me any help with this set?

A. 1. It is practically impossible to say just what is wrong with your set, unless we are able to see the same, and hear how it works. It may be that your radio frequency amplifying tubes are poor, or that you are supplying too much or too little current to them. Also, your potentiometers may not be adjusted to the best positions.

LIGHTNING DANGER

(182) Baird Fellows, Salisbury, Missouri, says that he is contemplating the erection of a radio station and is going to place his aerial on masts which will be erected on the tops of two buildings about 180 ft. apart. He asks:

Q. 1. Will there be any danger from lightning with the aerial?

A. 1. There is very little danger from lightning if the aerial is properly grounded when not in use.

Q. 2. The masts are to be guyed with galvanized iron wire. Should these guy wires be insulated?

A. 2. The guys should be insulated by inserting strain insulators about every 20 ft.

Q. 3. Will the above mentioned aerial be satisfactory for transmission?

A. 3. The aerial which you mention would be entirely too long for transmission. You should reduce its entire length to about 60 ft. for this work.

EXTENSION PHONES ON A RADIO SET

(183) Mr. Edmond Burke, Kansas City, Mo., wants to know:

Q. 1. How can I connect a pair of phones to my radio set so that the occupants of the house some distance away can listen in on the concerts? My set consists of a detector and a two stage amplifier.

A. 1. By running two wires from your house to your neighbor's, and connecting one end of the pair to your instruments, and a pair of phones to the other end, the radio music may be heard in the other house. If you also wish to listen in at your home at the same time you may connect your receivers in series or in parallel with the two wires, as is found best by trial.

RADIO SET IN A PHONOGRAPH CABINET

(184) Wm. D. Fox, Philadelphia, Penn., refers to the radio set illustrated and described in the June, 1922, issue of SCIENCE AND INVENTION, on page 156, and asks:

Q. 1. Could this set be used in connection with a loud speaker and what type would be best?

A. 1. The set you mention could very well be used with any form of loud talker; this would do away with the need of head phones.

Q. 2. Could this set be incorporated in a phonograph cabinet.

A. 2. Of course, this set could be incorporated in a phonograph cabinet, but since it has quite complicated controls, it would take some space.

Q. 3. Since I have had no experience in radio, I would like to have some informaion as to how to begin.

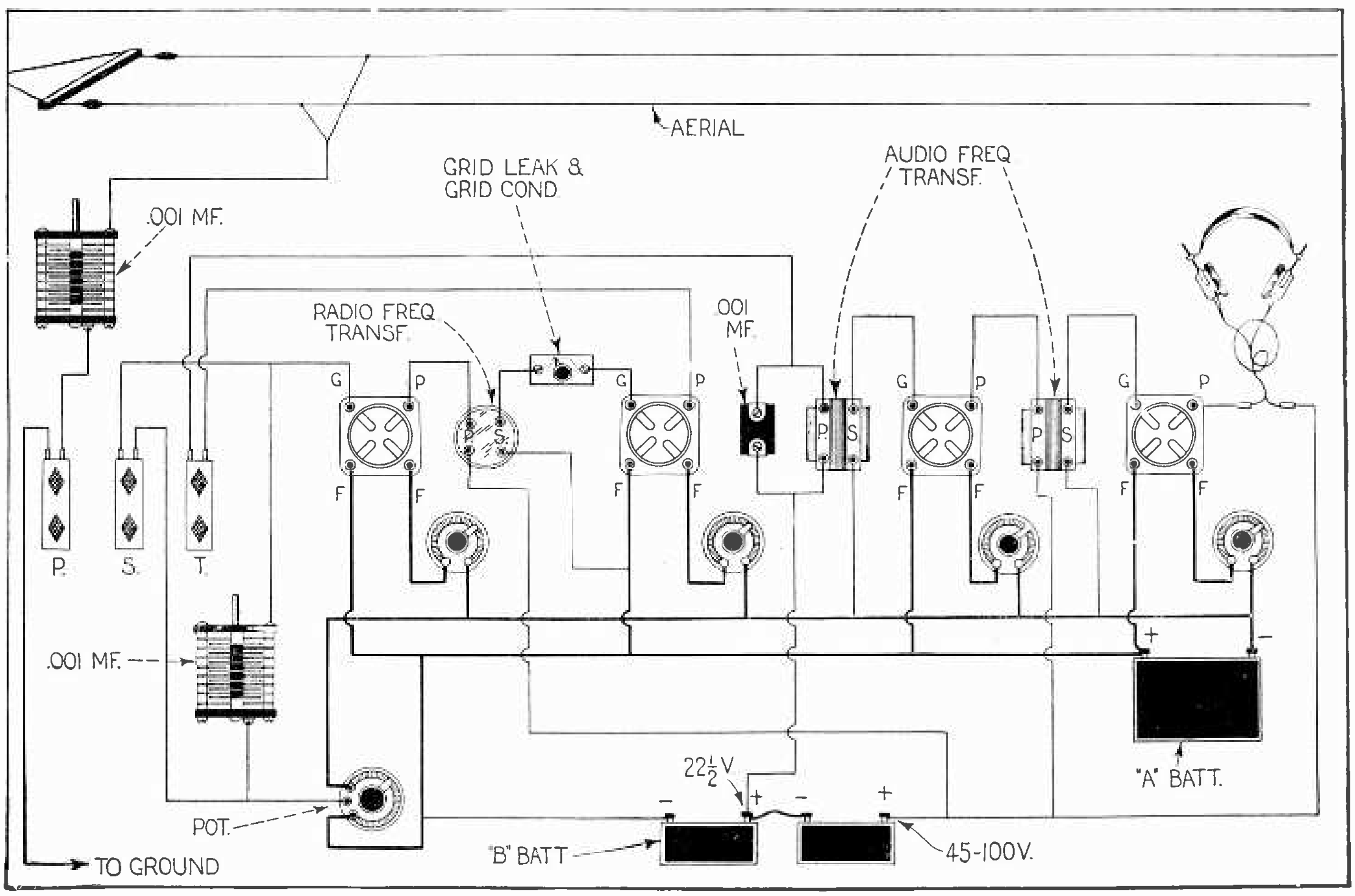
A. 3. A receiving set of this type is not advisable for the beginner in radio. You should start with a simple crystal or single tube receiver, and gradually enlarge this set as you become more familiar with the workings of the same.

SHIELDING

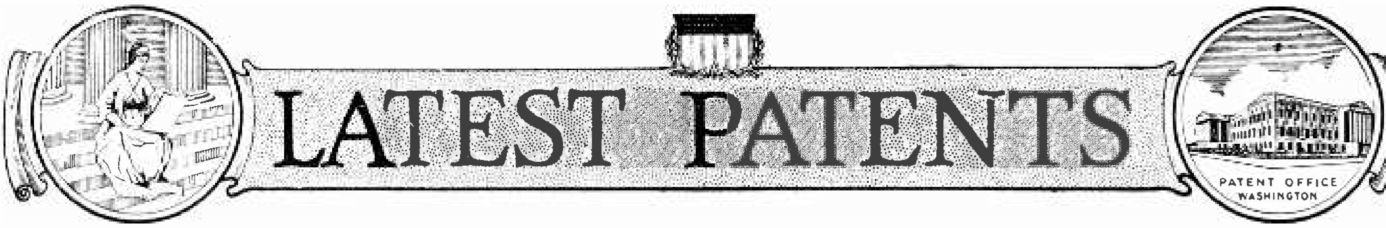
(185) Carl H. Fastje, Denison, Iowa, says that he has had considerable trouble with his radio receiving set in that whenever he brings his hand near the controls he hears a loud whistle and when he has a station tuned in and removes his hand the signal disappears. He asks:

Q. 1. How can this be eliminated?

A. 1. It is desirable to shield all the instruments of a regenerative receiving set, in order to reduce body capacity, and prevent the circuits from "howling." This may be done by fastening aluminum plates to the back of the panel, directly in the front of the tuning instruments, and connecting the same to a ground such as a water pipe, or to the ground post on the set. Be very careful in installing the instruments that you do not short circuit them on the aluminum plates. Everywhere that a hole is drilled in the panel and through the aluminum plates, the hole in the plate should be made larger than the hole in the panel. In this way any bolts or machine screws passing through the panel will not touch the plates and become short circuited. The rotary plates of variable condensers should be grounded, not the stationary ones.



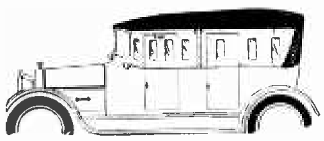
A Long Wave Receiver Employing Honeycomb Coils For Tuning, Using Feed-Back Regeneration Through One Stage of Radio Frequency Amplification With the Addition of Two Stages of A.F. Amplification. The R.F. Transformer Should Respond to the Entire Band of Wave-Lengths.



AUTOMOBILE CURTAIN

(No. 1,451,255 issued to Frederick J. Drekmeier.)

A new way of securing automobile curtains to a touring car and likewise of concealing them when not in use is described in this patent

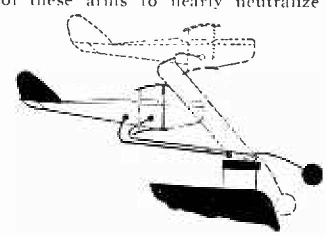


The automobile curtain itself is folded up and when in this folded condition falls down in the vacant space immediately back of the front seat. The fasteners for the curtain are few, although several rods run vertically through it in various places. Of particular interest is the L-shaped rods fastend to each door when the curtain is up. It now becomes possible to open the doors of the touring car without unhooking or otherwise disturbing the curtain protection, inasmuch as a portion of this swings open with the door.

MINIATURE AIRPLANE ATTACHMENT

(No. 1,458,278 issued to Henry Cave.)

As will be readily seen in the illustration, the inventor proposes to attach to the radiator cap of an autombile a miniature airplane. This is held in position by two arms capable of moving freely, but so arranged that the plane is always maintained in a horizontal position. A balance weight is secured to one of these arms to nearly neutralize

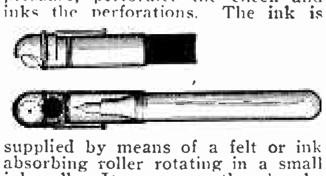


the weight of the airplane itself. When the vehicle speeds along, the action of the air on the wings of this airplane will cause it to rise, and the height to which it ascends will be directly proportional to the speed of the machine and also the speed of the wind. The plane will thus be caused to rise and fall to the amusement of the occupants of the machine and those who may be watching it. This position of the plane is shown in dotted lines in our illustration. There is no doubt but that a novelty of this nature will find a very ready market if placed before the public at a reasonable price.

CHECK PROTECTOR

(No. 1,452,674 issued to Albert E. Barnes.)

In the drawing, one will see in the top of the fountain pen cap, differing only from the ordinary cap in that the same is provided with a cutaway portion, a mutilating and inking mechanism. This mechanism, a small wheel, is provided on its surface with sharp projections, which when brought to bear upon the face of a check and moved in contact with it, but under pressure, perforates the check and inks the perforations. The ink is

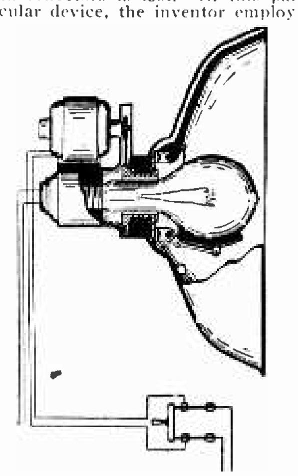


supplied by means of a felt or ink absorbing roller rotating in a small ink-well. It consequently absorbs the ink from the well and transmits it to the roller. The cap is so arranged that too great a pressure cannot be applied to the mutilating mechanism, assuring the user of perfect results and of a non-smudged check.

LIGHT-CLEANING APPARATUS

(No. 1,455,773 issued to James A. H. Bell.)

In factories where a great amount of dust is found, the electric light bulbs and reflectors are liable to be coated with grime after a short time, and it becomes necessary to employ someone to clean them very frequently; otherwise much of the lighting value of the lamps and reflectors is lost. In this particular device, the inventor employs

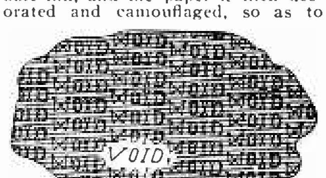


a motor securely fastened to each of the reflectors. The motor is operated at intervals, and, when so operated it causes a wiper to pass around the inside of the reflector cleaning it, and likewise removing any dusty accumulations on the lamp bulb. An automatic trip draws both the wiper of the reflector and bulb away from their respective surfaces when the motor stops.

SAFETY PAPER

(No. 1,454,837 issued to Burgess W. Smith.)

This paper is to prevent erasures or alterations on checks, drafts or other valuable instruments. On the paper are the words "void," printed thereon with indelible ink. Upon these words another series of letters or marks are printed in erasable ink, and the paper is then decorated and camouflaged, so as to

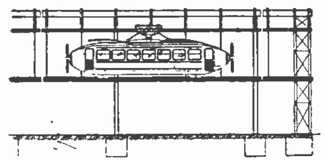


obliterate the outlines of the permanent matter. When an attempt is made to alter the check, the hidden words "void" are brought out. This safety paper was described more fully in the August, 1922 issue of this journal, long before the patent was issued.

AERIAL TRANSPORTATION

(No. 1,459,495 issued to George Bennie.)

Transportation by suspended vehicles is not new. In this system a car is suspended from main supporting rail by means of bogeys, and is provided with spring controlled guide wheels or pulleys which engage laterally with the guide rail below the car. As will be seen in the illustration, the vehicle is provided with lifting planes to reduce its weight, the effect of which may be reversed or otherwise adjusted, to enable the craft to be driven in either direction. The cars are likewise fitted with a propeller at either end. When the car has obtained suitable headway, the lifting planes are either manually or automatically adjusted, imparting to the car a tendency to rise and thereby reduce the tension on the supporting springs, and consequently the fric-

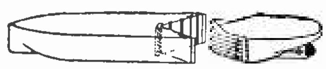


tion on the supporting members. The bogeys at no time leave the track. When it is desired to stop the craft, either the rear propeller may be operated and the lifting planes turned downward so as to increase the friction of the rollers on the track, or brakes may be used for the same purpose.

SECTIONAL VESSEL

(No. 1,458,134 issued to Paul A. J. M. Constan.)

In an effort to eliminate the disadvantages incident to the towing of vessels in bad weather, the following device has been patented. Essentially it consists of a navigable unit in two parts, each part constituting a separate vessel, but the said two parts are capable of being rigidly connected together, so as to form one single vessel of normal outline, the after section containing engine and propeller drive. The front of this thrust tug is V-shaped like a horizontal wedge, and this portion fits into a corresponding vertical recess in the stern of the forward vessel. At the bottom of the V, a slotted groove will be seen into which the hooking T-shaped tenons pass. When these are in position, a lever causes them to turn, so that they will assume a position at a right-angle with the groove. The bolts are then tight-



ened and the vessels appear as one. Inasmuch as each of the hulls are similarily constructed, three or four hulls may be joined together at one and the same time. When it becomes necessary to separate the vessel into its component sections, water ballast is admitted into the front part of the tug, and the rear part of the hull, to maintain the sections on a level keel.

PISTOL TARGET FINDER

(No. 1,452,651 issued to Charles H. Norrlin.)

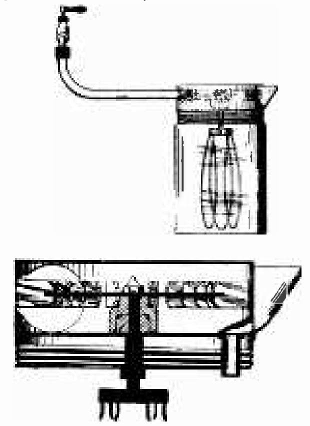
As our sketch clearly indicates, this patent is merely a combination of a tubular flashlight and a holder, whereby it may be attached to a regulation revolver or other fire-arm. It will be noted that clamping members or brackets are secured to the flashlight at either end. Between these two members a long rod is fixed. On this rod a shorter member capable of sliding is found. This is, however, kept in a more or less fixed position by means of a coiled spring at either end of the shorter member. The shorter member likewise is rigidly attached to

the revolver by means of two thumb bolts and a saddle. It is evident therefore, that the recoil of the revolver will not materially effect the flashlight on top, and thus the filament of the bulb there found which would ordinarily be broken after a series of repeated shocks, is quite safe from injury.

MOTOR-DRIVEN MIXER

(No. 1,454,223 issued to Roy W. Poor.)

If this little household utility is placed on the market soon, we feel quite sure that it will meet with a favorable sale. It consists of a small water motor fixed to the top of a cap, which in turn is made to fit a Mason jar. The apparatus is so arranged that a water turbine here formed will rotate a wire egg-beater when it is put into action, due to the water

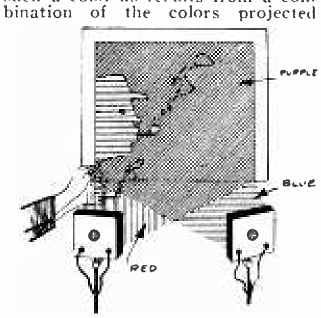


current acting upon the blades of the turbine. A large opening permits the water to flow out again into the waste. As will be noted in our illustration, a spout leads through the top of the cover to the interior of the jar, and through this spout the ingredients for making mayonnaise and other materials may be poured, and when thoroughly beaten, may be removed without disturbing the motor element.

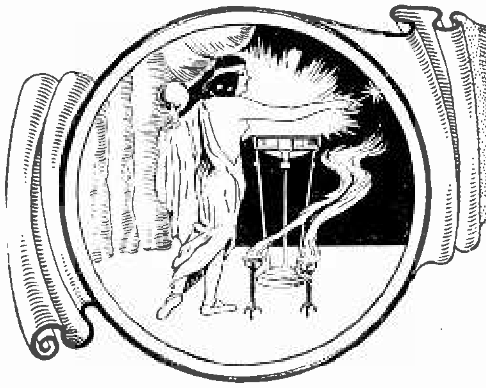
SCENIC EFFECT FOR SHADOWGRAPHS

(No. 1,451,046 issued to William Maxwell.)

It is well known that if lights of different colors are thrown upon a screen to cover the same surface the lights will combine to form such a color as results from a combination of the colors projected



For instance, if a red light and a blue light are both projected upon the same screen, the resultant combination will give purple, and if yellow and blue lights are used, the illumination will be green. If on the other hand, an object, for instance the hands of a shadowgraph expert, are introduced into the projected rays of one of the elements, the effect will be to cut off, as our illustration shows, the red rays, and the object itself will show its silhouette form in blue, whereas the rest of the screen is purple. If yellow and white lights are used it will be found that the white light is so powerful that it completely absorbs the yellow, but when an object is held in front of the projector transmitting the white rays a yellow image will appear on the screen. By combining colors and changing them, very beautiful effects may be obtained.



THE ORACLE

The "Oracle" is for the sole benefit of all scientific experimenters. Questions will be answered here for the benefit of all, but only matter of sufficient interest will be published. Rules under which questions will be answered:

1. Only three questions can be submitted to be answered.
2. Only one side of sheet to be written on; matter must be typewritten or else written in ink, no pencilcd matter considered.
3. Sketches, diagrams, etc., must be on separate sheets. Questions addressed to the department cannot be answered by mail free of charge.
4. If a quick answer is desired by mail, a nominal charge of 25 cents is made for each question. If the questions entail considerable research work or intricate calculations a special rate will be charged. Correspondents will be informed as to the fee before such questions are answered.

TELEPHONE TRANSMITTER QUERIES

(1530) Felix Grandich, New York City, wants to know:

Q. 1. Why is granulated carbon used in a telephone transmitter?

A. 1. Granulated carbon is used in a telephone transmitter, because when the diaphragm is vibrated by the sound waves, the carbon is alternately compressed and released, which changes the resistance of the circuit, and therefore, allows a greater or lesser current to pass through.

Q. 2. Is there any other method of transmitting voice by telephone without using granulated carbon?

A. 2. There are several other types of transmitters in use besides those using granulated carbon. One of the best of these is the carbon ball transmitter, which employs a number of carbon balls, set in depressions in a plate, and on which the diaphragm rests.

BLUING GUN BARRELS

(1531) E. B. Mitchell, Wiggins, Colo., asks the Oracle:

Q. 1. Can you tell me how I can blue shotgun and rifle barrels, and how old barrels can be re-blued?

A. 1. Methods for bluing gun barrels have been published time and again in various departments of this magazine. However, we will repeat a method for this work herewith.

Dissolve 4½ ounces of hyposulphite of sodium in one quart of water. Also dissolve 1¼ ounces of acetate of lead in one quart of water. Mix the two solutions and bring to a boil in a stone pot. After having thoroughly cleaned the barrel, coat with the hot solution using a piece of sponge tied to a stick of wood. When the color develops to the desired extent, wash with water, dry with a piece of flannel, and finish with boiled linseed oil.

ELECTROLYTIC RECTIFIER QUERIES

(1532) E. W. Ludwig, Havana, Cuba, says that he is having considerable trouble with his electrolytic rectifier, as gas is continuously given off from the jars and they become extremely hot in a very short time. He states that he is unable to obtain very pure chemicals and asks us if we can tell him what can possibly be wrong with his apparatus.

A. 1. The only trouble which we can see that can be wrong with your rectifier, is that you may not be using pure chemicals. Since, as you state, it is difficult to obtain these in your city, we would advise that you try anyone of the following solutions, the ingredients of which may be easily obtained:

Saturated solution of sodium phosphate.
Saturated solution of sodium bicarbonate.
10 per cent solution of sulphuric acid.
10 per cent solution of hydrochloric acid.
Saturated solution of table salt.

Any of these solutions may be used to advantage, as they are all tested and will work.

Q. 2. How is the rectifying film on the aluminum electrode to be formed?

A. 2. After setting up the rectifier and connecting it correctly, connect two 100-watt lamps in parallel, the set to be connected in series with the A. C. side of the line. Now short-circuit the D. C. side for about five minutes, and the rectifying film will be formed.

WARM WATER IN A VACUUM

(1533) J. W. Larvin, Pasadena, Texas, says, A claims that if a vessel of warm water be placed in a vacuum the water will freeze. B says that the water will not freeze. He asks:

Q. 1. Who is right?

A. 1. B is right. The water will not freeze. In fact, if a high enough vacuum could be produced, the water will begin to boil, due to its own latent heat and will be chilled, even if not frozen. However, the instant the water started to boil, vapor would be given off and the degree of vacuum lowered, whereupon the water will cease to boil, until such a time as the vacuum were brought to a high enough point again, at which time the same process will be gone through once more.

ELECTRIC PUMP CONTROL

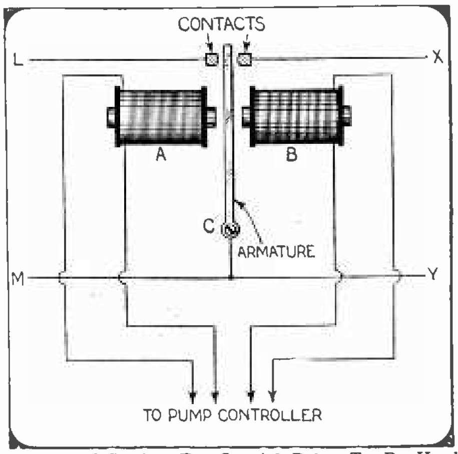
(1534) Roland Holloway, Maryville, Mo., requests:

Q. 1. Can you tell me how I can construct an apparatus which will turn an electric current from one magnetic field to the other on an electric pump, by means of electro-magnets?

A. 1. We gather from your question that you wish to use some sort of a relay arrangement to close two different circuits. We give herewith sketch of a suggestion for a relay of this type.

A and B are magnets placed end to end with a small gap between faces of their poles, and an iron armature, pivoted at one end, C, is placed between the poles. The other end of this armature is free to swing, and to close a circuit with the contacts when pulled to one side or the other.

The wires X and Y are connected to one of the magnetic fields of your electrical pump, and the wires L and M to the other magnetic field. Now, when magnet B is magnetized, it will attract the armature, and close the circuit, XY. When the circuit for magnet B is broken, and the circuit through magnet A is closed, the circuit LM will also close because the armature will swing to the other contact. Not knowing how you desire to control the currents in your magneto, we can only indicate the connections.



Suggested Design For Special Relay To Be Used In Controlling Electric Pump.

TEAR GAS

(1535) Roy Gravatt, Cheyenne Wells, Colo., asks:

Q. 1. How can tear gas such as used in the late World War be prepared?

A. 1. A very effective tear gas which is chemically known as benzyl bromide, C6 H5 CH2 Br, may be formed by treating boiling toluol with bromine, preferably in sunlight. It may be formed more rapidly if a halogen carrier is present.

GENERATOR QUERY

(1536) J. H. Smith, Moretown, Vt. says that he has a generator which is supposed to deliver 52 volts at 2,800 R. P. M. This generator has no magnetism at all on the poles. He says that the only way he can make this machine generate any current at all is by the use of batteries on the field coils. He asks:

Q. 1. Can you tell me what is the matter with this generator?

A. 1. In all probability, your D. C. generator is of the separate excited field type and it is necessary to use an external battery to excite the field sufficiently to cause generation. In this case, the pole-pieces are of soft iron; it therefore would be impossible to magnetize them permanently.

A UNIVERSAL MOTOR

(1537) Lowell S. Ellis, Warren, Mass., says that he has an electric fan motor which was designed to run on D. C. It is series wound and he wants to know how to change it so that it can run on A. C.

A. 1. Since your motor is series wound, you should be able to connect it directly to the 110-volt alternating current leads and the same will rotate on A. C. as well as D. C. Try this and see whether or not you can get proper results. This motor must be started by hand.

CURRENT CONSUMPTION OF FLASH-LIGHT BULBS AND GRAVITY CELL QUERIES

(1538) H. H. Cowley, Woodstock, Ont., Canada, wants to know:

Q. 1. What is the amperage consumed by a 3.8-volt and 2.8-volt flashlight bulb?

A. 1. The amperage consumed by a 3.8-volt and a 2.8-volt flashlight bulb is very low, generally only about 3-10 ampere or less.

Q. 2. What kind of a cell is best for closed circuit work and how is it made?

A. 2. The best kind of a cell for closed circuit work is the Edison primary battery. This will be very difficult to construct, and attempts at the construction by amateurs have been far from satisfactory. If you use a gravity cell you would get very good results indeed. This consists primarily of a copper finger sector placed in the bottom of the jar. Into the jar a quantity of concentrated copper sulphate solution is then poured, and some copper sulphate crystals thrown into the liquid. These do not dissolve, of course, but remain at the bottom, being used up very slowly, as the age of the battery increases. The jar having been half filled with the aforementioned fluid, a quantity of zinc sulphate, solution is added. A "crowfoot" zinc is then placed in the top of the cell just below the water.

SOUND FILTERS

(1539) A. W. Chambers, Birmingham, Ala., asks:

Q. 1. Is there any device on the market that will filter out one particular sound from a number of sounds which are forced into it?

A. 1. There is no apparatus which would do exactly the work you mention, but there are several which will, out of a number of sounds, reinforce a certain one of them, so that it may be heard above the others. A resonator will do this work as will also a tuned string.

Einstein's Restricted Theory

By VLADIMIR KARAPETOFF

(*Continued from page* 442)

between the point A and his respective origin (O or O^1), and (b) the instant at which the flash took place. Einstein claims that the two observers will not only record different results, but that this difference cannot be explained on our "common sense" point of view, that is, by figuring out in the usual way their relative positions at the instant of the flash, and knowing the relative velocity q. Einstein's formulae can be graphically interpreted as shown in Fig. 3, and the model in Fig. 1 is based on this interpretation.

THE TWO SET OF AXES FOR THE SAME EVENT

In Fig. 3, OB is a general reference axis (universal bisector), OX is the axis along which the S observer plots his distances and OT is the axis along which he plots his time intervals. The angle XOT is *greater* than 90° by an angle a which depends upon the relative velocity q of the two observers, in a manner explained below. On the model the circular scale on top is directly calibrated in values of q, in per cent of the velocity of light. The S^1 observer plots his distances along OX^1 and his time intervals along OT^1. The angle X^1OT^1 is *less* than 90° by the same amount a.

Let A in Fig. 3 represent the instantaneous flash of light mentioned before and let the S observer find that the flash took place at the distance OC from his origin, and that his clock read time CA, where CA is drawn parallel to OT. Then the S^1 observer will find the distance from his origin to be equal to OC^1 and the time equal to C^1A. The fundamental assumption made in the construction of the model is that *an event represented correctly for one observer is also represented correctly for the other, provided that it is measured in the proper directions of time and distance axes.* The proof of the correctness of the model lies in the fact that the relationships derived from it and represented by algebraic equations check with Einstein's equations. We shall now show the use of the model on a few examples.

SHORTENING OF LENGTHS

Let the S^1 observer mark a length x^1 in his system, parallel to the direction of the relative motion and let S be asked to measure this length while the two observers are in relative motion. To S^1 the "event" is represented by two parallel lines, OT^1 and AD (Fig. 4), the distance OC being equal to x^1. By the fundamental assumption, the same two parallel lines represent this event correctly for S, who, however, measures his distances along OA, and thus finds a length x smaller than x^1. This apparent shortening of a moving length is known in physics as the Fitzgerald contraction, and its magnitude depends upon the relative velocity q of the two observers. In Fig. 4 this contraction depends on the angle a which in turn depends upon q. The value of the ratio of x to x^1 comes out from the model exactly as predicted by the theory.

THE CLOCK OF A MOVING OBSERVER SEEMS TO RUN SLOW

Let the S^1 observer have a clock at his origin O^1 (Fig. 2) and let him be instructed to give a signal after his clock ran, say for an interval of time t^1 from the instant at which O and O^1 were in coincidence. For S^1 the event is represented by the point E (Fig. 4), where $OE = t^1$ is the agreed interval of time. In order to find out what time S will read at the instant of the signal, we draw EF parallel to OX. Then $OF = t$ is the interval of time measured by S, and FE is the distance between O and O^1, Fig. 2, at that instant. We see that t is greater than t^1; hence we conclude that S will claim that the S^1 clock was slow. Again the ratio of t^1 to t comes out from the model exactly equal to the value predicted by Einstein.

VELOCITY MEASUREMENT

Let a small body A, say a bullet or an electron, move at a uniform velocity along XX^1 (Fig. 2) and let each observer be asked to measure this velocity relatively to his own system. The event itself is represented in Fig. 5 by the straight line OH. For such a line both observers will find that the distance covered is proportional to the time elapsed, so that they will agree that the material point A is moving at a uniform speed. By definition of velocity, it is equal to the distance covered in unit time. Hence, if we lay off OF equal to unit time, and draw FD parallel to OX, the point of intersection, C, will determine the length $FC = v$, which is the velocity as measured by S. In accordance with our agreement regarding units, v is expressed as a fraction of the velocity of light.

To find the value of the velocity v^1 of the point A, as measured by the S^1 observer, we repeat the same construction for his axes, that is, we lay off $OF^1 = 1$ and draw F^1D^1 parallel to OX^1. F^1C^1 is then equal to v^1.

Let OH be turned by a small angle clockwise. This means a point for which both observers will measure higher velocities. Finally, when OH coincides with OB, the velocity measured by S will be $FD = 1$ and that measured by S^1 will be $F^1D^1 = 1$. It will thus be seen that the universal bisector OB represents a point moving at the velocity of light with respect to both observers. In other words, *Einstein's postulate of relativity, viz., that the velocity of light is the same for all observers, follows directly from the arrangement of the axes in the model, and need not be a separate assumption.*

THE ANGLE BETWEEN THE AXES

We can now readily see what value the angle a between the axes must have. To the S observer, the S^1 system is moving at the velocity q, while to S^1 himself he is stationary. Hence, to S^1 the axis OT^1 represents his own stationary position, independent of time, while to S this axis represents a point moving at the velocity q. By laying off $FG = q$ from point F, we find the position of the axis T^1. This determines a the angle a for a given q. But to S^1 the observer S is moving at the same velocity q in the negative direction. By laying off $F^1G^1 = q$ on the extension of D^1F^1, we find the position of OT if OT^1 is given. From the geometry of the figure, these two relations can exist simultaneously only if one set of axes, say TOX, comprises the angle $90° + a$, while the axes T^1OX^1 are drawn at an angle $90° - a$. The triangle OGF has a right angle at G, so that the value of a can be readily obtained for a desired q, or vice versa. Those familiar with trigonometry will see at once that $\text{Sin } a = q$, where q must be expressed as a fraction of the velocity of light. The circular scale shown in Fig. 1 is marked directly in per cent of velocity of light using the above relationship between q and a.

DETAILS OF THE MODEL

The model (Fig. 1) is made of sticks of wood, 2.5 cm. by 0.5 cm., and the four axes are about 100 cm. long measured from O. The bars OT and OX^1 are permanently fastened at right angles to each other, and so are the bars OT^1 and OX. The bars OT and OX extend to the left and with two other short bars form a rhombus. The bisector OB is made of steel bar 1.5 cm. by 0.5 cm. and is 100 cm. long, measured from O. It also extends to the left of O and serves as a guide for the rhombus. The rhombus is provided with a slider and a set screw at the extreme left, and in this way the two sets of axes can be fastened at any desired angle a (or speed q) to each other. The speed scales (DF and D^1F^1 in Fig. 5) are also shown in Fig. 1. They are provided which saddle sliders at D and D^1 and are pivoted at F and F^1. The holder and some other sticks shown on the bisector to the right serve for various experiments that can be performed with the model.

Speed

By HAROLD F. RICHARDS, Ph.D.

(*Continued from page* 451)

New York, and found to function with great precision. Five hydrophones for receiving sound waves under water are located at known distances from a central recording station on the shore, and a 1-pound bomb of TNT is detonated electrically at a known distance from the shore. The same pulse of electricity which serves to detonate the bomb also causes a radio transmitter to send out a radio signal, and since radio travels fast enough to go seven times around the world in a second, the times required for the radio signal to reach the shore, a distance of perhaps 10 miles, may be neglected in comparison with the time required for the sound to reach the various hydrophones under water. The arrival of the radio signal is recorded photographically on a moving film, which is calibrated to the thousandth part of a second, and subsequently, when the various hydrophones receive the sound impulse, they also produce, in succession, records on the moving film. Thus a single photographic record indicates the times required for the sound to travel from the bomb to each of the hydrophones. The arrival of the sound pressure-wave at a hydrophone induces an electric surge in the string galvanometer wire. Meanwhile, a beam of light from an electric arc is producing on the moving film a continuous record of the position of the string, and so a sudden deflection of the string introduces a corresponding nick in the photographic record. Furthermore, the beam of light is regularly being interrupted by the spokes of a wheel, rotated at constant speed by a tuning fork controlled motor; every time a spoke interrupts the beam of light a photograph of the spoke is produced, in the form of a fine transverse line, on the moving film. In the apparatus described, the interruptions occur every 0.01 second, and the distance on the film corresponding to this interval is 1.1 millimeters, which can later be measured to the tenth part. Thus the film, when developed, is found to be ruled with lines by which time can be measured to 0.001 second, and it is a simple matter to determine the times required for the sound to reach the different hydrophones. From this data, together with the known distances of the hydrophones from the bomb, the speed of sound in water (about 4,700 ft. per sec.) is easily calculated.

The Planet Mars

By PROF. WILLIAM H. PICKERING

(*Continued from page* 432)

MARS' TEMPERATURE LOWER THAN OURS

Where the snow is melting the temperature is necessarily 32° Fahrenheit. In general, the mean temperature of the planet is probably about 20° lower than that of our Earth, but the polar regions are warmer than ours during their long summer season. The extremes of temperature are much greater than with us, and frost occasionally forms, even in the daytime, on the equator. Clouds are a frequent phenomenon, especially at sunrise and sunset. They often conceal large areas of the surface near the melting polar caps. During the latter part of the Martian August, and through September, snow storms are of frequent occurrence near the north pole, and the deposited snow is readily seen through the telescope.

WHAT ARE THE "CANALS" OF MARS?

In 1892, the canals in the dark regions were discovered, and it was shown that the supposed canals crossed the supposed seas, it became at once evident either that the canals were not real water canals, or else that the seas were not real seas.

It was then decided that a suggestion made in 1888, that both were due to vegetation, was more probable, and this may be described as until recently the practically universal opinion among planetary observers. On the other hand, the idea that this vegetation is supported by invisible central irrigating pipes or ditches, and the later suggestion that the flow in these ditches is maintained by a gigantic artificial pumping installation, while still popular with a certain section of the general public, have now by the overwhelming majority of the practical observers of the planet both been consigned to the scrap heap.

Investigators now believed that since these regions evidently change color with the seasons, that they may perhaps be arid, but certainly cannot be described as permanent deserts. A suggestion has recently been made that the broader and fairly permanent canals mark the curved courses of nocturnal rain showers. Unlike the maria, they never appear green. It is shown that on Mars any such heavy precipitation would almost certainly occur at night, when the planet's atmosphere would experience a very striking fall of temperature, much more marked than ever occurs upon our Earth. These canals are moreover curved in the right direction as determined by theory, and indicate by their radius of curvature wind velocities differing but little from those that are often observed in our own upper atmosphere. It is as yet too early to say how well this explanation will withstand the assaults of time, but we may say that at least it seems promising.

The shorter narrow canals, which always appear rather late in the season, may perhaps also be explained that way. We have not yet found out just what is their cause. Of course, they may be artificial. There is no reason why the assumed Martians should not plant their crops, or shrubs, wherever they choose. They may have a special fancy for a linear distribution, but the chances are that there is some definite natural reason for it, probably associated with dense nocturnal fogs, and the arrangement of the hills and valleys. We have found canal-like markings quite as artificial looking upon the Moon.

MOON HAS CANAL MARKINGS ALSO

Mars, in fact in numerous respects, presents a much greater analogy to our Moon than it does to the Earth. Both Mars and the Moon possess canals, which differ from one another mainly in size, rather than in appearance, the lunar canals being very much smaller. Oddly enough, both are found to shift across the surfaces of their respective planets, and in general towards the Sun. Several of the Martian canals shift as much as 150 miles, the lunar ones being smaller shift much less, only two or three miles. It was hoped at first that a study of the lunar canals would help us to understand the Martian ones, but it only appears to deepen our uncertainty. It seems improbable that a lunar canal should be due to meteorological causes, but a traveling variety of vegetation on either planet seems still more unlikely.

DOUBTFUL THAT MARS IS INHABITED

If our own Earth were viewed from the same distance that we view Mars, never less than 35,000,000 miles, it is certain that we should not be able to detect the slightest evidence of civilization upon its surface, nothing but the constant changes induced by the action of the gigantic forces of nature—the melting of the snow, and the advance of vegetation with the progress of the seasons. Man's puny efforts could nowhere be seen. There is no evidence that the Martians, if they exist, are more advanced than ourselves. They may be much less so—perhaps they are only brutes or insects. Indeed, the only reasons ever advanced for assuming their superiority is the now discarded pumping theory, with the associated idea that the canals were laid out in straight lines, and with the belief that their planet is perhaps older than ours. The last really might be a good reason, if Mars were like the Earth, but we know that it is not. It may be that it is better adapted to the development of an advanced civilization, or it may be that it is less so. We should not expect to find any advanced civilization upon the Moon even if we waited a hundred thousand years for it. It is pleasant to dream of the Martians as being far more advanced in knowledge than ourselves, and there is no harm in our doing so, so long as we are ready at all times to admit that the idea has not the slightest foundation, either for or against it, in fact as far as known.

Experimental Electro-Chemistry

(*Continued from page* 458)

success can be had with some grades of denatured *grain* alcohol. A nickel gauze electrode should be used, although sheet nickel can be used. This forms the cathode. A porous pot or cylinder containing a cold saturated solution of sodium carbonate with an electrode of lead serves as the anode. The porous pot is inserted into the jar or beaker. This serves as a permeable membrane to separate the two electrolytes. Keep the whole cell well cooled and pass a current of about 6 amperes through the cell for 3 hours and then cut the current strength down to about 2 amperes for another hour. Replace alcohol which is lost by evaporation.

The large red crystals of azobenzene should then be collected and preserved. They are rather impure.

An ingenious device now having a wide sale is illustrated in Fig. 4. It consists of two electrodes fitted in a handle. The electrodes are an alloy of aluminum, containing about 97 per cent aluminum, the other constituents being silicon or magnesium or both. When the electrodes are connected to the 110-volt mains and thrust into a liquid, aluminum hydroxide forms about the electrodes and is thrown off.

Motor Car Leaps, Loops and Skids

By HAROLD F. RICHARDS, Ph.D

(Continued from page 454)

however, not so simply explained. There is great doubt as to whether the blow-out furnishes a legitimate excuse for accidents, many drivers reporting that a blow-out had not appreciably increased the difficulty of steering; and I remember one driver who, after losing an entire rear wheel, held the road easily for thirty yards, with the end of the axle dragging on the ground. We may, however, note the following effects of a sudden blow-out.

(1) The axle is inclined towards the side blown-out, producing a cone-effect which causes the car to turn in the direction of the blow-out. This, of course, is due to the sudden deflation of the tire.

(2) There is a slightly greater pressure on the blown-out tire than on its mate, due to the inclination of the axle, which tends to produce a slightly greater traction on the side where the blow-out occurs, resulting in a twist of the car. This effect is small.

(3) Due to the collapse of the tire, the wheel affected gives the road a sudden push, of its own account, entirely independent of the motor. This effect is produced by the sudden concentration of the mass of the tire closer to the rim, which decreases the moment of inertia of the wheel. The angular momentum of the wheel tends to remain constant, however, and since the moment of inertia of the wheel has become less, the wheel tends to speed up, acting like a flywheel and thus pushing the car unsymmetrically. The principle is exactly the same as that involved when a weight fastened to a string is swung around in such a manner that the string winds up on the finger. As the weight approaches the finger, due to the shortening of the string, it goes faster and faster. Just how important this effect is, in relation to the other results of a blow-out, can hardly be determined without performing exact experiments, and it appears that such experiments have not yet been carried out.

It may be said, in conclusion, that the cone-effect, due to the sudden inclination of the axle, which, of course, is not corrected for by the differential is probably the greatest factor in causing loss of control when a tire blows out, and that the flywheel action of the affected wheel comes second in importance. The explosive action, in spite of the sound of it, is not a factor; the air simply leaves and the wheel drops. The experience of many motorists suggests that a blow-out, with its accompanying surprise and wrench of the steering wheel, is seldom a sufficient cause to account for complete loss of control.

Spectroscopes—How to Build Them

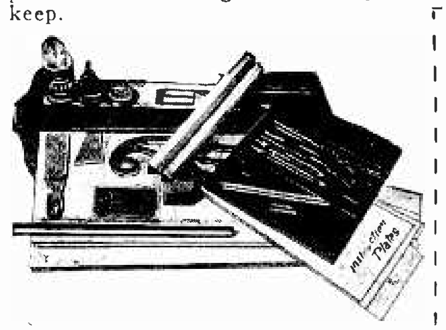
By C. E. BARNS

(Continued from page 444)

potassium, etc.—a small particle of the substance experimented upon is held in the flame by a short length of platinum wire with pincers. The bright lines of these various substances will instantly be visible.

A PORTABLE HAND-SPECTROSCOPE

A most beautiful and serviceable hand-



spectroscope, suitable alike for laboratory experiment and for the observatory in connection with a telescope (as well as forecasting the weather with amazing accuracy) is what is known as the Amici type, containing three, or, better still, five prisms in combination: three crown and two flint. The series may be purchased—prisms of one-inch base, cemented together in proper form—for twelve dollars or thereabouts; but the blank prisms of borosilicate crown and dense flint may be had for a third of that sum, and the grinding of the prisms to form can be undertaken by the novice possessed of the necessary lens-grinding tools.

A grinding tool with a plane surface screwed to the end of the vertical shaft moved by the worm-screw is the main implement for getting the prism to true form and also for polishing. A vernier caliper and a goniometer for measuring angles with great accuracy are quite essential during the grinding process so that all prisms of the series will fit together. These are afterwards cemented together with Canada balsam and blackened with vegetable black and lacquer. When the fine-emery work is complete, the surfaces are polished on a disc of hard cartridge paper affixed to the revolving tool with thin photographer's paste and ironed down smooth, dry jeweller's rouge, oxide of iron or putty powder being used as the polishing agent. A wax-pad, as used in lens-polishing, will not do, as it tends to turn the edges.

ADVANTAGES OF THE AMICI PRISM

The advantage of the Amici series is that the spectral image widens with each prism traversed; and being set in alternate units, the emergent beam is on a line with the incident ray, and there is no turning of telescope and collimator to reciprocal angles in order to pick up the spectrum. In other words, the entire system, from eyehole to slit, is in a straight line. The whole instrument, as compact as a field-glass when closed up for the pocket or traveling-bag, is very powerful. Indeed, one of the chief advantages of this portable spectroscope is that it may be slipped on to the inner tubes of the eyepiece system of a refractor for stellar observation. In this case the objective serves as a collimating lens; and as a star is only a point of light anyway, the slit-cap is also removed from the spectroscope, the elongated image of the star serving the purpose of the slit. True, carrying the star-image through a slit increases its definition and makes clearer the spectral lines—or, rather, dots—distributed along the thin brilliant line of many colors, often twice or three times the entire breadth of field, but a star-spectrum is very difficult to pick up through a slit; and without a driving-clock, harder still to hold.

The difference between the spectrum of the sky on a bright clear day and one in which the heavens are slightly overcast is very marked. The bright telluric lines of vapor, even in currents at very great heights, are soon discerned by those skilled in the use of this little instrument. The darkening, paralleling and obscuring as with a haze of the otherwise sharp hard dark "D"-line of sodium in the solar spectrum is itself an almost infallible criterion.

Popular Astronomy

By ISABEL M. LEWIS, M.A.

(*Continued from page* 431)

tory of Carleton College, Northfield, Minn. will also locate here to photograph the corona and star-field surrounding the sun with an 8-inch lens, and to obtain photograph of the flash spectrum.

WHERE PARTIAL ECLIPSE WILL BE VISIBLE

In all sections of the United States outside of the path of total eclipse the sun will be *partially eclipsed*, in fact, the partial phase of the eclipse will be visible over all of North America and the northern part of South America. The maximum obscuration at any point will depend upon the distance of the place from the central line, the size of the eclipse decreasing as the distance from the central line increases. The moon's shadow will first strike the earth at sunrise a little to the southwest of Kamchatka in Asia. From this point the path of total eclipse, which is a little under one hundred miles in width, will cross the Pacific Ocean in a southeasterly direction, grazing the Aleutian Islands, but passing over no land in its course until it arrives at the Santa Barbara group of islands off the coast of California shortly after local noon. The shadow of the moon sweeps over this part of its course in about an hour and a quarter with the tremendous speed of approximately half a mile in a second. After touching the coast of Southern California the shadow passes over Lower California, Mexico and the Gulf of Mexico to Yucatan, and thence south of the West Indies to a point near the Lesser Antilles, where it leaves the earth at sunset. About one hour and forty-five minutes are required for its journey from the western coast of Lower California to the point where it leaves the earth. The entire extent of its path from Kamchatka to a point in the Atlantic near the Lesser Antilles, a distance of over five thousand miles, is covered in three hours. As it sweeps past the Aleutian Islands it is early in the morning, local time; it is about 1 o'clock, Pacific Time, when it reaches San Diego and Ensenada; 2:15 p. m., Mountain Time, when it comes to Hermosillo, and 2:35 p. m. when it passes Cuencame. At 3:28 p. m., Central Time, it reaches Tampico on the Gulf of Mexico, and as the sun is setting it passes off of the earth in the vicinity of the Lesser Antilles.

As the Alaskan peninsula, the western and southern parts of the United States and the West Indies lie comparatively near to the path of total eclipse, the partial eclipse will be largest in these sections as well as in all parts of Mexico and Central America. In the New England States the maximum obscuration will be about 40 per cent and in eastern Canada it will be even less.

CAUSE OF TOTAL SOLAR ECLIPSE

It is probably known to everyone that a total eclipse of the sun is due to the passing of the moon directly between the sun and the earth. It is not so generally known that eclipses can *only* occur when the moon is at, or very close to, the nodes of its orbit which are the two points 180° apart where it crosses the ecliptic or plane of the earth's orbit around the sun. The moon passes through each node of its orbit once every month, but eclipses will not occur unless the earth, sun and moon are in line when the moon is at or near one of its nodes. This is bound to occur twice a year at intervals of six months, when the sun is near the nodes of the moon's orbit and the times when eclipses both of sun or moon are liable to occur are spoken of as the *eclipse seasons*. That eclipses do not occur in the same months each year is due to the fact that the positions of the nodes of the moon's orbit are slowly shifting at a rate which causes them to complete one revolution around the

(*Continued on page* 489)

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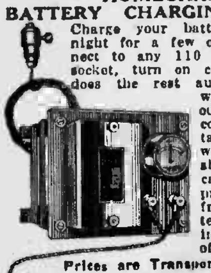

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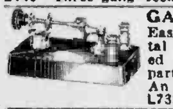

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150	600- 2000	L306	.63	L326	1.17
200	900- 2500	L307	.72	L327	1.26
250	1200- 3500	L308	.78	L328	1.35
300	1500- 4500	L309	.82	L329	1.36
400	2000- 5000	L310	.97	L330	1.57
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600	4000-10000	L312	1.27	L332	1.78
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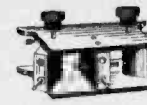

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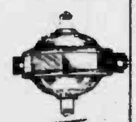
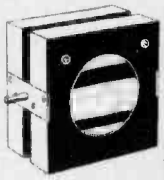
L907 3½ in. Diam. for ¼ in. shaft. Ea...35c

OUTDOOR LIGHTNING ARRESTER



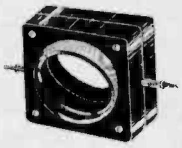
L980 Price....$1.58
Protect your instruments with this lightning arrester. You cannot afford not to. Weatherproof porcelain case. Air gap type. Permanent. Durable. The most practical quality arrester obtainable. Underwriters approved.

VARIOMETER



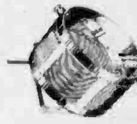
L410—Completely assembled, price $2.10
Perfect in design and construction. Accurate wood forms of genuine solid mahogany. Correct inductive ratios. Solid baked windings. Positive contacts. Highest efficiency. A real bargain.
L411—Not assembled nor wound but all parts complete except wire, including winding form, $1.48

MOULDED VARIOMETER



Polished black moulded rotor and stator forms. Maximum inductance with greatest efficiency and minimum distributed capacity. A high grade durable instrument that will make up into a set you will be proud of and will get the best results. Wave length 180 to 600 meters. 4¼ in. square, 1⅞ in. thick.
L412 Price including mounting brackets $2.95

IMPROVED 180° VARIO-COUPLER



L418 Price....$2.48
Our price shows you a big saving. An instrument of highest quality. The most efficient type of coupler. Insures sharper tuning and louder signals. Primary and secondary wound on genuine bakelite tubes. Secondary connections through soldered flexible cables eliminates contact noises. Primary has 7 taps. Can be panel or table mounted. Range 180 to 650 meters.

MAGNET WIRE

Insulated copper wire. Best quality even drawn wire, one piece to a spool. Prices quoted are for 8 oz. spools.

Double Cotton Covered		Enameled Insulation		Green Silk Covered	
Number L990		Number L992		Number L991	
Gauge	Price	Gauge	Price	Gauge	Price
18	.50c	20	.45c	20	$0.78
20	.60c	22	.55c	22	.90
22	.75c	24	.61c	24	1.05
24	.85c	26	.65c	26	1.18
26	.95c	30	.70c	30	1.70
28	$1.15	32	.79c	32	2.05
30	1.65	36	.98c	36	2.75

STRANDED ANTENNA WIRE

Cabled of fine copper strands. Very flexible. High tensile strength. Best for aerials.
L248—100 ft. coil 72c L249—500 ft. coil $3.20

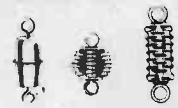
SOLID BARE COPPER WIRE

Solid bare copper wire for aerials, leads or wiring instruments.

Solid Bare Copper Wire, size 14
L240—100 ft. coil 49c L242—500 ft. coil $2.35

Solid Bare Copper Wire, size 12
L244—100 ft. coil 67c L245—500 ft. coil $3.05

ANTENNA INSULATORS



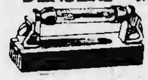
L260 Size 1x3¼. Two for....17c
L267 Size 2¼x3¼. Two for....55c
L264 Size 1½x4. Two for....69c
L266 Size 1½x10½. Two for....$1.28

L260 L262 L264-6

PHONE AND GRID CONDENSERS

A compact style of condenser that is very satisfactory. Conducting sheets and dielectric are wound on fiber strip with eyelets for mounting and connections. Each..8c
L170 Phone Condenser .001 Mfd.
L172 Phone Bridging Condenser .0005 Mfd.
L174 Grid Condenser .00025 Mfd.
L175 Condenser .006. Each....25c
L176 Grid Condenser .00025 with pencil mark leak. Each....12c

TUBULAR GRID LEAKS AND CONDENSERS—MOUNTED STYLE



Very convenient. Permits quick change of leaks or condensers of varying capacities.
Grid Leaks Price Each....24c

Resistance		Resistance	
L850	.5 Meg.	L855	2. Meg.
L851	1 Meg.	L857	3. Meg.
L853	1.5 Meg.	L859	5. Meg.

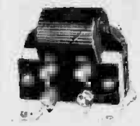
GRID AND PLATE CONDENSERS

Price, each....55c
L832 .0001 Mfd. For special circuits.
L834 .00025 Mfd. For U.V.201 and Cun. 301
L836 .0005 Mfd. For U.V.200 and Cun. 300

MOUNTINGS

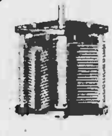
Bakelite base. Spring clip contact.
L840 Single mounting. Each....32c
L842 Double mounting. Each....57c
L844 Triple mounting. Each....76c

OUR SPECIAL AUDIO FREQUENCY AMPLIFYING TRANSFORMERS



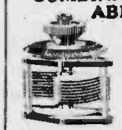
As high as three stages can be used without howling due to proper impedence ratio, minimum distributed capacity, low core losses and proper insulation. Mounted style has bakelite panel with binding post connections. Unmounted has core and coils assembled with two holes in core for fastening to apparatus.
L234 10 to 1 Mounted. Each....$3.48
L235 10 to 1 Unmounted. Each....2.95
L236 3 to 1 Mounted. Each....3.40
L237 3 to 1 Unmounted. Each....2.85

BARAWIK SPECIAL PANEL MOUNTING VARIABLE CONDENSERS



L812 43 plate .001 Mfd...$1.73
L813 21 plate .0005 Mfd. 1.43
L814 11 plate .00025 Mfd. 1.32
L815 3 plate Vernier....89
These are especially high grade condensers and we guarantee them to be mechanically and electrically perfect. Fine polished end plates of heavy bakelite. Shafts ¼ inch diameter. Sturdy, heavy aluminum alloy plates perfectly spaced to insure smooth, even reliable capacity. Our low prices save you money. These condensers are of the very best make and are not to be compared with many inferior cheap condensers offered. We guarantee them to please you or your money back.

COMBINATION VERNIER VARIABLE CONDENSERS

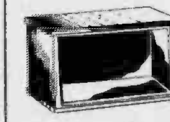


L824 23 plate .0005 Mfd. with dial and knobs. Price....$2.89
L826 43 plate .001 Mfd. with dial and knobs. Price....$3.45
The latest improvement in condensers consists of regular variable condenser controlled by large knob and dial mounted with a three plate vernier condenser, which is controlled by separate knob mounted above knob on dial. This arrangement permits of very fine tuning. Compact convenient mounting on panel. High grade design and construction. Finely finished.

STANDARD BRAND HEADSETS

L754 Baldwin Type C with universal jack plug....$11.75
L755 Baldwin Type C unit with cord $5.50
L756 Red-Head, 3000 ohm.... 5.78
L768 Brandes, 2000 ohm.... 5.40
L770—2000 ohm Barawik.... 3.75
L751 Murdock 56, 2000 ohm.... 4.20
L752 Murdock 56, 3000 ohm....4.95
L764 Frost, 2000 ohm....4.20
L766 Frost, 3000 ohm....$4.85
L758 Western Electric, 2200 ohm....9.50

CABINETS



Fine looking cabinets solidly built. Elegant hand rubbed finish. You will be proud of your set mounted in one of these cabinets. Hinged tops. Front rabbeted to take panels. Panels not included. Prices are transportation paid.

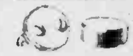
Panel Size	Inside Dimensions High	Wide	Deep	Art. No.	Price Each
6x 7"	5½"	6½"	7"	L420	$2.48
6x10½"	5½"	10 "	7"	L422	2.75
6x14"	5½"	13½"	7"	L424	3.30
7x14"	6½"	13½"	7"	L423	3.60
7x18"	6½"	17½"	7"	L426	3.90
7x21"	6½"	20½"	7"	L425	4.20
9x14"	8½"	13½"	10"	L428	3.70
12x14"	11½"	13½"	10"	L430	4.40
12x21"	11½"	20½"	10"	L432	5.25

RADIO "BAKELITE" PANELS

Notice our very low prices on this fine quality material. We supply genuine Bakelite, Condensite Celeron or Formica, all of which are materials with practically identical mechanical, chemical and electrical properties. Machines well without chipping. Won't warp. Waterproof. Highest mechanical and dielectric strength. Attractive natural polished black finish which can be sanded and oiled for extra fine work.

Panel Size Inches	⅛" thick Art No.	Price	3-16" thick Art No.	Price	¼" thick Art. No.	Price
6x7	L450	$0.50	L460	$0.75	L470	$0.98
6x10½	L451	.75	L461	1.11	L470	1.47
6x14	L452	1.05	L462	1.56	L472	2.05
7x14	L458	1.20	L468	1.80	L478	2.40
7x18	L453	1.55	L463	2.30	L473	3.10
7x21	L457	1.78	L137	2.65	L477	3.68
9x14	L454	1.60	L464	2.30	L474	3.10
12x14	L455	2.10	L465	3.10	L475	4.15
12x21	L456	3.15	L466	4.65	L476	6.20

VARIABLE GRID LEAK



Pencil mark type. Resistance may be varied exactly as needed. L160 Each....19c

GRID CONDENSER

L162 Mounting holes spaced to fit lugs of above leak. Cap. .00025 MF....8c
L163 Same as 162 but higher grade. Enclosed in metal case....39c

THE BARAWIK CO.

Chicago's Original Radio Supply House Beware of Imitators

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NATIONAL
Apparatus of Standard Quality and Value

Simplicity and Perfection

The Monodyne circuit is one of the most radical advances in Radio engineering. Parts heretofore considered essential are omitted. One simple tuning control gives selectivity, equal if not superior to sets costing hundreds of dollars.

Only One Control
All Wave Lengths

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For Reflex and Crystal Sets

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TUBE SET
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Entirely New Circuit

No Storage Batteries

Uses but one dry cell tube, preferably WD-12, or any other standard dry cell tube. Local broadcasting comes in astonishly loud and clear, without distortion.

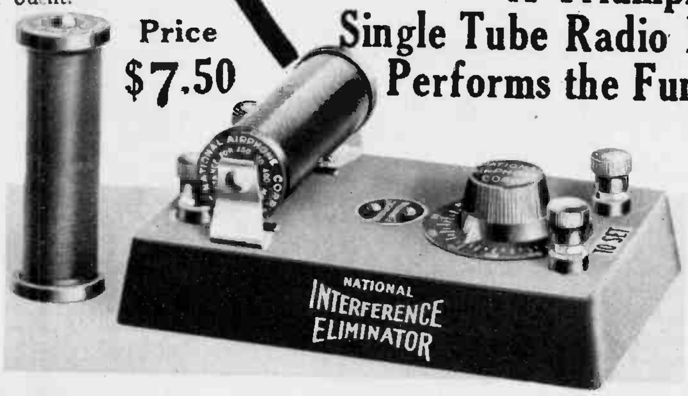
$10
Including Two Inductance Coils Without Tube

A Triumph in Radio.
Single Tube Radio Frequency Receiver Performs the Function of 2-Tubes

(NATIONAL) INTERFERENCE ELIMINATOR

The National Interference Eliminator can be used with any and all radio outfits no matter what make, tube or crystal sets. Will bring in stations you never heard before. Nothing else required with set as illustrated. Just connect it with two short wires to your outfit.

Price
$7.50



An Absolute Necessity to Clear Reception
Eliminates broadcasting and code-signal interference
Can be used to increase or shorten wave lengths

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ON THE
MONODYNE

Having purchased your Monodyne set I was more than pleased over the results obtained from it. I think it is one of the best one-tube sets on the market today.
I have heard the following long distance stations—WDAF Kansas City, WDAP Chicago, WSB Atlanta, WOO Philadelphia, WGY Schenectady, WOC Davenport, and a Canadian station whose call letter I could not obtain.
Using hook-up No. 4 gives very selective tuning and volume. Your set cannot be praised too highly.
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Please send me prepaid the articles crossed, for which I will pay postman on delivery the advertised price.

One ☐ National Monodyne
One ☐ Interference Eliminator
One ☐ Panel Detector

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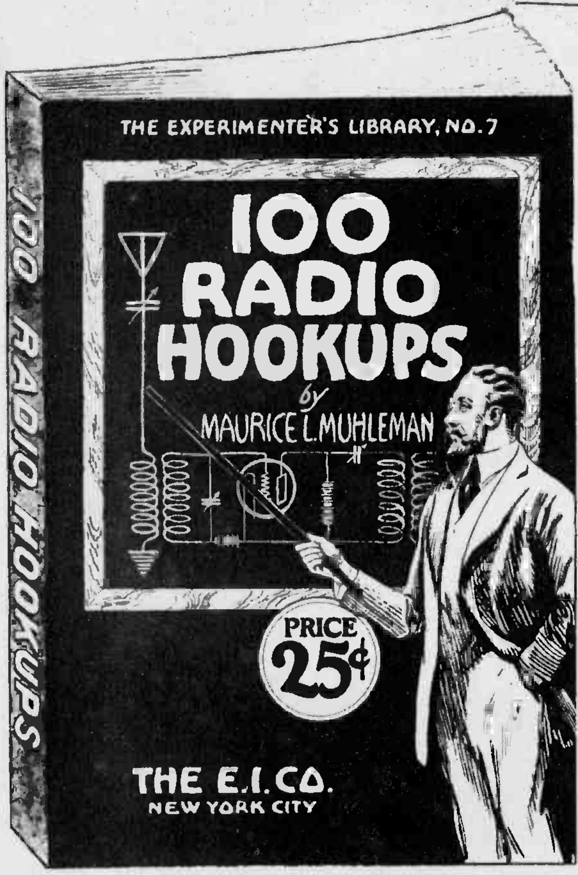
NEW 25c BOOKS

That Every Novice or Amateur Needs



100 Radio Hook-ups

By M. L. MUHLEMAN

A book for both the novice and advanced radio amateur containing a varied selection of hook-ups from the simple crystal to the more elaborate circuits, with a circuit for every requirement. Crystal hook-ups, combined crystal with radio and audio frequency amplifiers, non-regenerative, and regenerative vacuum tube circuits with and without radio and audio amplifiers. Amplifier units, with straight jacks, filament and switching arrangements, power amplifiers, choke coil, resistance coupled and transformer coupled radio frequency amplifiers.

Includes all of the latest, one and multi-tube hook-ups including the numerous types of Reflex, super regenerative, super-Heterodyne, Neutrodyne, Reinartz, Flewelling, and Bishop. The values and constants of all apparatus employed in the hook-ups are given. A list of radio symbols is included, which are of material help to the reader in determining the meaning of the conventional hook-up diagrams. The text includes much helpful information.

52 Pages—Two-Color Cover .... **25c.**

This book covers in comprehensive form, the fundamental principles of tuning. The characteristics of radio waves are fully described and illustrated. Illustrations are used so that the non-technical reader can easily understand the identical actions as applied to radio. Several chapters are devoted to the use and functions of all radio apparata. The book describes how to tune such sets as the Reinartz, Flewelling, Neutrodyne, radio frequency amplifier receivers and other.

52 pages,
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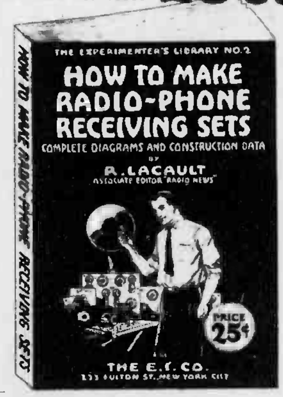
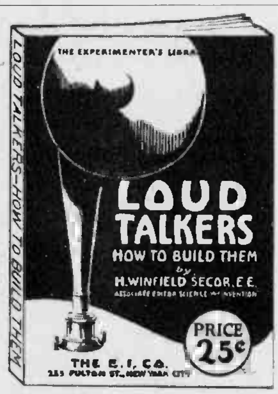
A non-technical book for the beginner. Gives complete constructional data on the building of a complete Crystal Detector Set, Tuning Coil, Loose Coupler and a Single Audion Tube Set with Amplifying Units. It furnishes all dimensions and working drawings of every part that must be constructed by the amateur. Written in plain, simple language that anyone can understand. The opening chapter gives a complete description of the theory of radio and tells what it's all about, teaching the principles of wireless so that the constructor knows what he is doing.

48 Pages, 26 Illustrations
Bound in Beautiful Two-Color Cover. Size, 5½ x7½ in. Prepaid........... **25c**





This book describes and gives complete data for building two distinct types of loud talkers. One chapter deals with improvised loud talkers, and gives complete instructions on how to build suitable horns for use in loud receivers of the Baldwin and other types. In preparing these designs, the point has been constantly kept in mind to use the simplest parts possible, so that anyone can build a successful loud talker, equivalent to the commercial types, costing $40.00 or more.

48 pages, Profusely Illustrated
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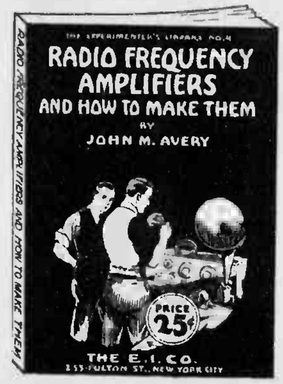
This book is for the more advanced amateur, showing the construction of the Radio Frequency Amplifying Transformer and giving complete constructional data. It shows the application of Radio Frequency to amplifying units that the amateur may already possess and gives 15 hook-ups showing practically every use Radio Frequency Amplifying Transformers can be put to.

32 Pages, 15 Illustrations
Bound in Beautiful Two-Color Cover. Size, 5½ x7½ in. Prepaid......... **25c**



A complete list of dealers carrying these books will be found on page 512

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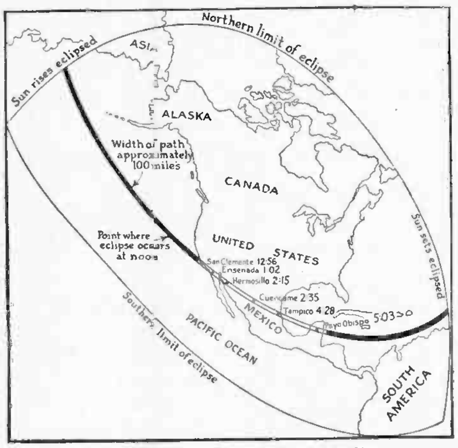
THE E. I. COMPANY (THE CONSRAD CO. Selling Agents) 233 Fulton St., N. Y. City

Popular Astronomy

(*Continued from page* 484)

ecliptic once in about nineteen years. As a result eclipses occur at a different time each year, but always at intervals of six months. Two weeks following or preceding the time of solar eclipse there may be also an eclipse of the moon, when earth, sun and moon are again in line with the *earth* between the sun and moon, which occurs at the time of full moon. There are usually two lunar eclipses a year and there may be three under certain circumstances. There are years when no lunar eclipses occur, but there must be at least two *solar* eclipses each year and there may be as many as five. The greatest number of eclipses that can occur in a single year is seven, five of the sun and two of the moon. All solar eclipses are not total. In some cases the axis of the shadow-cone cast by the moon passes just clear of the earth above one of its poles without striking the surface of the earth at any point and in this only the partial phase of the eclipse is observable upon the earth's surface.



The Path of Coming Solar Eclipse.

The principal work that will occupy the attention of the eclipse expeditions will be the procuring of negatives to test the Einstein effect.

A "DX" Receiver with Novel Tuner

By P. A. PRICE

(*Continued from page* 473)

The antenna rotor, or primary, is made up of a bakelite, hard rubber or wooden ball-type rotor fitting snugly but free to turn in the stator tube. It is wound with 35 to 40 turns of No. 22 silk-covered wire.

The tickler rotor is similar to the primary, but is wound with 55 to 60 turns of No. 26 silk-covered wire. 30 feet of No. 22 wire is used on the antenna rotor and 45 feet of No. 26 is required for the tickler.

The condenser bank to be used in the aerial circuit is constructed of five fixed condensers of the following capacities: two .0005, two .00025, one .001 M.F. They should be strung upon a two-inch brass bolt in this order: .001, .0005, .00025, .0005, .00025. The second and third condenser, that is, the .0005 and .00025 condensers nearest the .001 condenser should be connected together at the top and this condenser and each one of the other condensers connected each to a separate tap in the condenser bank switch set.

It will be noted that when the switch-arm is placed on the tap connected to the .001 condenser, a capacity equal to that of a 43-plate variable condenser is obtained. When the switch-arm is placed on the tap which is connected to the .0005 and .00025 condensers hooked together, a capacity is obtained approximating that of a 37-plate condenser. When the switch-arm is turned to the tap connected with the .0005 condenser a capacity approximating that of a 23-plate condenser is obtained, and when the .00025 condenser tap is used, a capacity approximating that of an 11-plate condenser is available.

Five condensers are indicated in the foregoing description of the condenser bank but this number may be reduced to three; .001, .0005, and .00025 M.F. The grid condenser should be .00025 M.F. preferably mica, and the grid leak should be five or six megohms.

Variable Stars

By RUFUS O. SUTER, Jr.

(*Continued from page* 437)

denly blaze forth from invisibility, attain great brilliancy, then gradually fade away until no longer discernible. (See illustration 1, Fig. C.)

2. Stars which periodically pass from a maximum brightness to a minimum faintness. The time elapsing between two successive maxima or minima, the period is more than 100 days.

3. Stars that are irregular in period and range.

4. Stars whose periods are less than 100 days, and fairly regular.

5. Stars that are regular in period and range.

Sir Norman Lockyer's meteoric hypothesis explains both the peculiar fluctuations and the apparent motion. Groups of meteors entered a nebulous area, where their repeated collisions caused frequent conflagrations of varying intensities. The greatest conflagration was the nova. The lesser conflagrations, illuminating different parts of the nebula, gave the effect of motion. It is interesting to consider that if Kayser's theory is right, the new star actually burst forth at about the time Galileo discovered the moons of Jupiter. The light bearing the image of the catastrophe has just reached us.

The novae are no more baffling than the long period variables of Class 2, whose spectra undergo changes almost coincident to the light cycle. At minimum either titanium oxide predominates, or carbon, or elements which have not been recognized in earth. During the rise to maximum, hydrogen lines appear which become most distinct at actual maximum, and are accompanied by iron, magnesium, and calcium vapor. With the decline in brilliancy, these latter elements frequently outshine the hydrogen. At minimum the stars display the same spectra as originally. Long period variables are usually characterized by a comparatively rapid ascent to maximum, where they remain a few days, then more gradually descend to minimum, in which condition they remain the greater part of the time. (See illustration 1, Fig. A.)

The most plausible theory is an adoption of Sir Norman Lockyer's meteoric hypothesis. If a mass of meteors were conceived as traveling in an orbit around a larger and more diffuse mass, situated toward one side of the orbit, frequent collisions between the two groups of meteors would cause periodic outbursts of brilliancy. The maxima, in accordance with observation, would differ slightly from time to time. (See illustration 2.)

Entirely distinct from the novae and long period variables, are the stars of Classes 3 and 4. The fluctuations in the former case are without regularity; and in the latter are so complicated that a long series of ob-

(*Continued on page* 498)

How Submarines Dive and Rise

By IRWIN R. FAHRLAENDER

(*Continued from page* 426)

underneath the boat, he would be able to support the residual weight of the boat in the palm of his hand.

Numerous other tanks are contained in the vessel, such as the trimming tanks, which, as the term implies, affect the position of the vessel; they are used to correct the fore and aft trim, which may vary by the shifting of weights such as men, stores, torpedoes, fuel, lubricating oil or fresh water.

The larger submarines are not so sensitive, but in the smaller types in use a few years ago, it was customary for the crew to remain at their stations without moving, unless the command officer ordered a man to move forward or aft so many feet. In fact, we used to say we had to keep our hair parted in the middle, the boats were so sensitive.

Our ballast tanks are full, fore and aft trim is established, also the buoyancy. We are now ready to go about our business, which is either a practice run, an attack on a real enemy, or last but not least in the eyes of the enlisted men, to earn the extra compensation every qualified submarine man gets for every time he submerges. Officers do not get extra compensation.

To the uninitiated the interior of a submarine seems fairly crammed with pipes, valves, gauges, wheels, shiny steel and brass fittings, voice tubes, etc., all apparently pushed into place without much system, but let me tell you every so-called gadget has its use and is an essential part of the mechanism necessary for the successful operation of a submarine.

"SILENCE" THE ORDER WHILE SUBMERGED

Let us look around the boat. We see the crew apparently sitting around doing nothing, probably conversing in whispers, as silence is insisted upon while submerged, but every man is at some particular station, waiting for orders to perform some necessary task.

The commanding officer and the second lieutenant are at the periscopes keeping a sharp lookout. Another officer or (chief petty officer) keeps an eye on the crew.

In the torpedo room we find the torpedo tubes at the forward end, and in the racks on either side the spare torpedoes, tools, etc., and under the deck the fuel oil tanks.

In the next compartment we find the crew's quarters with lockers and bunks, and underneath, if we take up the deck, will be found part of the storage battery, which is used to supply power to the electric motors, which are used when submerged.

In the next room, called the C. O. C., you will find the entire control system of the boat. A mass of wheels, dials, levers and the automatic blow valve, a device set at a predetermined depth which will by means of compressed air, automatically expel the water from the tanks without human assistance.

Then we have the after battery compartment, underneath the deck of which we find another part of the storage battery. In one corner of this compartment we see the galley range which is heated by electricity, and a very complete outfit capable of producing anything from roasts to pastry. In various other places we find an ice box, lockers for dishes a folding table to eat from and more switchboards.

Next is the engine room which contains the powerful Diesel engines, which are used for surface running.

Some people have an idea that submarines always run submerged when traveling from place to place. If you stop to think, it will be readily seen that this would be impossible, as the storage batteries would become quickly exhausted especially at high speed.

It is possible, however, to remain submerged for long periods of time by running at very low speeds or by resting on the bottom of the sea. It is merely a question of battery endurance.

I hear you say air. It is perfectly simple. The air is purified from time to time and then we have the compressed air, too, to fall back on. Of course, staying submerged for 48 hours or longer is no joke, but it can be and has been done.

Aft of the engine room we find the motor room, containing the main electric motors, high pressure and low pressure pumps, a small lathe and drill press, and the usual shiny wheels and air compressors. There is no noise here either, except the low hum of the motors as they turn over, tended by the men on watch.

Again we go aft. We find ourselves in the tiller room, a small, cramped place, containing the rudder turning gear.

Having finished our superficial inspection of the interior of the boat, let us go back to the C. O. C., and see what has taken place. We are running at periscope depth (about twenty feet below the surface) taking it easy, keeping at the set depth as if running on a track, the helmsman steering by gyro-compass, but it seems to be getting rough on the surface, so to escape the wave motion we descend to, say 100 feet.

OBJECTS SEEN WHILE RUNNING SUBMERGED

By looking through the conning tower port holes, we can see the bow and the stern of the boat in the twilight, that is, if the water is clear, the propellers showing in vague blurs as they spin.

Especially if the boat is warm and stuffy one feels as if it would be nice to open the hatch and go on deck for a stroll in the cool green water, because it seems as if the boat were suspended and without motion until if we look down we will, if in shallow water, see the bottom of the ocean sliding by.

The question is often asked: "Do you see any fish?" No, not unless the boat is lying on the bottom perfectly still as the hum scares them away. But if you put on a diving suit, arm yourself with a spear and walk around you will see many kinds of fish, rocks of many fantastic shapes, coral and marine growth of various kinds.

We are ready to come up, so the commanding officer orders the main ballast tanks blown, which is done by compressed air, forcing the water out of the tanks; or by pumping—and once again we are on the surface and in the sunlight.

200 FEET A SAFE DEPTH

In the Holland type of submarine boats we note first the hull, which is almost circular in cross-section except aft where it is flattened, so as to allow for the attaching of the propellers and horizontal and vertical rudders.

The hull is designed to withstand a pressure of 88.8 pounds to the square inch, or in other words, must be able to descend a depth of 200 feet with safety. This test must be made before the Government will accept the vessel and must stand it without undue distortion of the hull or damage to any part of the same. Greater depths have been attained though not always by design, but usually through an accident. In fact boats have descended to three hundred feet and returned without being seriously damaged.

Upon the hull is riveted a non-water tight super-structure of light construction, which provides a working platform and housing for various things, such as pipe lines, rudder rods, bow rudders, anchor gear, exhaust lines, mooring lines, and material and stores not damageable by salt water.

Secured to the hull of the boat is the conning tower surrounded by what is known as fair water, then we see the periscopes, and the above water radio mast, also protected by a housing, and forward of the periscope we see the metal bridge screen. Other outside fixtures are the usual navigation lights, the underwater radio antenna and the clearing wires, which are strong cables stretched fore and aft. The clearing wires are so designed and placed, that in case the submarine should foul a net, the boat would slide underneath instead of being held fast. In addition to these clearing wires, the Germans used a heavy contrivance securely fastened to the bow which looked like a tremendous saw. The idea was that the momentum of the boat would cause the wires to be cut when making contact with the saw.

Looking forward again we see something projecting like the ears of a jackass. They are the bow-planes, rigged out from inside the boat and now ready for diving. These planes are operated from inside the boat in conjunction with the after planes, keeping the boat while submerged on an even keel or with but slight variations from the horizontal plane. The ship is steered in the ordinary manner and is provided with twin screws. Propulsion is by means of Diesel engines on the surface and electric motors while submerged.

THE ENGINES

The engines are either 2 or 4 cycle heavy oil, reversible or non-reversible, depending on the type in use, internal combustion engines using gas oil for fuel, ignited by the heat of compression instead of ignition by a spark as in gasoline engines.

Another feature of this type is the hollow keel which is used as a main drain, which is one of the main claims to superiority of the Holland type. The boats are also provided with anchors of two types, patent and mushroom, operated from inside the boat, so it is possible to anchor while submerged, a very handy method of lying in wait for the enemy, paying out the anchor cable, thus rising to the surface for a look, then heaving round and drawing the boat down to safe depths again with the least expenditure of energy and almost no noise.

THE 5-INCH DECK GUN

On deck we find a 5-inch quick firing gun, called a *wet gun* because it is always left exposed to the water when submerged instead of being housed. It is possible to get the gun into action as soon as the deck is out of water and the crew can get up out of the boat and should be blazing away in less than a minute after emerging from the depths, as ammunition is stored near at hand ready for use.

SPEAKING OF TORPEDOES

While on the subject of armament I will say a few words about the torpedoes and tubes. A modern American torpedo is driven by steam and air at a high speed for extremely long ranges. For the benefit of those unacquainted with the wonderful weapon, we will picture a shiny cigar-shaped cylinder provided with its own complicated motive power, its own steering and diving gear, in fact a miniature submarine, which after it once is started by air from the tube, is left absolutely to itself, speeding on its deadly mission like an arrow, automatically steering, keeping its depth, oiling its own machinery, generating its own power, and, as it speeds along, preparing the T.N.T. charge which is carried, for its explosion, which will happen regardless of whether the torpedo hits nose or tail first, or just sideswipes the vessel. Then goodbye enemy and torpedo, too.

Many people think that to disable a submarine all you have to do is shoot off a periscope. If that was all that could be done to a submarine, life would be a sweet dream thereon. There is usually another periscope in reserve and sometimes a third which is also an altiscope, used for searching the sky for aircraft.

HOW TO "BAG" A SUBMARINE

The things to do to bag a submarine is to shoot it full of holes before it can submerge, try to ram it and as you pass over the spot where she went down drop an assortment of those innocent looking cans (depth bombs) we used to see on the quarter deck of destroyers, which are filled with T.N.T. and can be set to explode at any depth, so to make life interesting for the submarine crew. It was customary for the destroyers to tear around like mad at high speed shedding bombs as fast as possible, which were set for both shallow and deep explosions, hoping that at least one would connect properly and destroy the submarine.

What is the submarine doing meanwhile? Trying, of course, to avoid the bombs by changing its course and using different speeds and depths, with all hands wondering how close the next one will be. Maybe the boat is damaged so that it cannot come up but goes down and down until finally it is crushed like an eggshell or maybe stops on the bottom in shallow water, helpless, the water pouring in, the crew working to repair the damage, finally giving up hope and trying to escape from the wrecked craft by expulsion by air pressure through the conning tower and coming to the surface to be picked up or to die as the circumstances may be.

Any number of wartime incidents could be related about damaged submarines both in our navy and in foreign navies.

So you see life in a submarine is not all beer and skittles, and it is most assuredly no place for weak sisters. But for real he-men who can take a few hard knocks and come up smiling, it is a mighty interesting life, with plenty of action.

When exigencies of the service permit, those men who desire long foreign cruises, are on request transferred to a submarine making such cruises. During the war the under-sea boats crossed the Atlantic with ease and the large fleet of submarines now on the Asiatic Station can stay at sea for four or five months if necessary.

The submarine service is an ideal place for anyone desiring to specialize in engineering, electricity or torpedoes and for anyone of energetic type it is the place for rapid advancement, not only on account of the expansion of the service, but due to the fact that everyone is always under the eye of the commander and it is very easy to form a correct estimation of a man's ability in a short time under such inspection.

Liquid and Solid Hydrogen in Quantity Production

By S. R. WINTERS

(*Continued from page 449*)

duplicate of the machinery employed in manufacturing liquid air. Moreover, the method of changing the atmosphere into a fluid is closely analogous to that of manufacturing liquid hydrogen. The difference in the two processes is this: In liquefying hydrogen, instead of starting with gas at ordinary or room temperature, as in the case of liquefying air, the compressed gas is first cooled to 200 degrees Centigrade below the commonly accepted zero point. This temperature is attained by the forced evaporation of liquid air under reduced pressure. With the exception of this one departure, the conversion of hydrogen into a fluid is in principle identical with the liquefication of air.

HOW GAS IS LIQUEFIED

The method of producing liquid air at the Bureau of Standards is, briefly, as follows: The atmosphere is first reduced to a high degree of compression, by the application of 3,000 pounds to the square inch. The resultant heat is removed and the air is partly purified. It is preferable, but not absolutely necessary, that the atmosphere be pre-cooled to a point of a few degrees below room temperature, after which it is passed through a heat inter-changer and permitted to expand to atmospheric pressure through a valve. The air in its expanded form, is then given passage back over the heat-changer as a means of cooling the incoming compressed air. Thus little cold is wasted. The apparatus then gets colder and colder until a portion of the air is liquefied.

Fortunately, however, the Fixation Nitrogen Laboratory of the United States Department of Agriculture has developed a method for determining the presence of nitrogen in hydrogen, which element is most troublesome in the production of liquid hydrogen. This method makes it feasible to analyze the gas at all stages of its manufacture and use, as well as to locate the sources of contamination. This means of analysis is being applied at the Bureau of Standards, where hydrogen for its own needs is being made electrolytically. It is assembled in a gas holder, containing oil instead of water, and is compressed into cylinders for storage. The hydrogen, as it comes from the generator, contains about one-hundredth of one per cent nitrogen. After the gas is compressed into cylinders, about two-one-hundredths of nitrogen is present. The oxygen that gains entrance into the generator is removed by a device which heats the gas sufficiently to cause the oxygen and hydrogen to combine. If any water is present, which presence does not offer a serious difficulty, it may be absorbed by ordinary drying agents.

Liquid hydrogen is produced at a temperature of 423 degrees Fahrenheit below the zero point of the Fahrenheit scale. This fluid, like liquid air, may be preserved in vacuum containers, the vacuum serving as barriers against the entrance of heat from the outside. Liquid hydrogen may be thus retained for a period of one or two days.

SOLID HYDROGEN

Solid hydrogen is being produced in the Low Temperatures Laboratory of the Bureau of Standards at the lowest temperature ever attained in Washington, D. C., and probably the lowest point yet reached on the thermometer scale anywhere in the United States—at 434 degrees Fahrenheit below the zero point. and only 25 degrees Fahrenheit above absolute zero.

Once gaseous hydrogen has been reduced to a fluid, however, it is comparatively easy to convert it into a solid. This is accomplished by further reducing the temperature—about eleven degrees Fahrenheit lower—of the liquid by rapid evaporation in a partial vacuum. Hydrogen in this state is the lightest solid known, being one-third lighter than cork. Solid hydrogen takes the form of flakes bearing a similarity to snow or ice, and it is well-nigh impossible to preserve this solidified element for even a period of a few hours. For instance, an attempt to carry the flaky substance for a distance of four or five miles proved futile, it having completely melted.

What Temperature Can the Body Stand?

By JOSEPH H. KRAUS.

(*Continued from page 429*)

when malarial fever might be indicated. If the temperature should rise on the first day to 106°, we know definitely that the patient has not developed typhoid fever, because typhoid seldom produces a temperature of over 104° in the evening of the first day, although temperatures of 105° in the evening and 104° in the morning which show a rather severe attack of this disease. may result disastrously during the third week of the attack. On the other hand, should the temperature be below 102°, it would indicate the commencement of convalescence or a relatively mild attack of this disease, and should the temperature increase above 99 but without attaining 102, and should the patient exhibit signs of pneumonia, we know that there is no soft infiltration of the lungs. A temperature of 104 in pneumonia cases indicates a severe attack. The same temperature in acute rheumatism is something to cause the individual to be anxious. Generally when the temperature rises steadily to about 106.3 to 107, the prognosis is very unfavorable, and a temperature of 110 is almost certain to prove fatal in diseased conditions. Nevertheless, there have been some remarkable reports which would tend to disprove the above statement. In cases of sunstroke, 110° is quite frequently found. In scarletina a case has been reported in which the patient developed a temperature of 112°, and in tetanus at the time of death a patient has exhibited a temperature of about 114.

A RARE CASE

It is doubtful whether anyone shall ever have another patient as remarkable as the one treated by E. E. Holt, M.D., of Portland, Maine, who is the founder of the Maine Eye and Ear Infirmary, and who was executive and senior attending surgeon of this infirmary for more than thirty years.

This patient, twenty-one years old, was treated for an ear condition from which she recovered; after an operation for the ablation of the left mastoid, she was discharged. A year later in 1901, following another operation, the temperature rose at first to 105.6° F. without any chilly sensations, giddiness or any other outward signs indicating fever conditions. There was another operation, and in twenty days the temperature rose to 108°. The skull was then trephined, and for fourteen days the temperature was normal, after which it rose again on one occasion to 108°. The temperature repeatedly rose from a point below normal, 97° to over 114°, almost daily, with the pulse running as high as 116 on rare occasions. The strangest fact was that temperatures in two different portions of the body were entirely different. Where one would register 114+ and break the clinical thermometers, the other extreme point where internal temperatures are taken, registered below 94, and consequently could not be recorded on the thermometer. A large number of thermometers were used and the temperatures taken by many surgeons. Two thermometers that registered only 114° were broken. Inasmuch as the patient was in the hospital, there was absolutely no chance of fraud. In this patient, however, although at times the pulse varied, it generally remained around ninety beats per minute, and the respirations were never far from normal. It was evident that there was a disturbance of the heat controlling centers, but why or how has never been determined. The patient subsequently was discharged as cured, left the state and on writing to the doctor more than a year later claimed she had no further trouble whatsoever.

From the above cases it is seen, therefore, that one cannot diagnose diseases by the thermometer alone; many other symptoms must be taken into consideration. Neither can we definitely state at what point on the Fahrenheit scale life will cease to exist. Some patients develop no increase of temperature whatever when they pass the Great Divide; others exhibit an extremely high fever. There is no point of definite demarkation.

WHAT HAPPENS IF THE ROOM TEMPERATURE IS INCREASED

In the graph on this page we show the effect of high temperatures on the human body in actual tests made by the U. S. Bureau of Standards, under the Division of the Bureau of Mines of the Department of the Interior. It will be seen that the zero on this graph represents the normal body temperature, and an increase of 3° was recorded in test conditions in cases where still air or moving air of 100° F. surrounded the subjects of the test. Even at a temperature of 95°, more than 2° F. rise in temperature was exhibited. Under these test conditions, and remaining at rest in the room, having a temperature of 95°, the body temperature was increased; the pulse rate increased; sweating was very profuse, the clothes being saturated with perspiration. Dizziness was experienced and an increase in depth and rate of respiration was found. Chilly sensations were developed in some subjects. If the air in the room were agitated, there was a slight rise or no rise in temperature, with a corresponding action on the part of the pulse. Sweating was profuse, but not sufficient to wet all clothing. No other untoward symptoms were produced.

IN A ROOM AT 100° F.

At 100° F. the following effects took place. The temperature of the body increased, reaching even 102.3° F., which is 2.3° higher than surrounding air. The pulse-beats varied and in some cases were 152 to more than 183 in others. Sweating was very profuse, the shoes being partly full of water. The test was very trying, dizziness and weakness being present, which symptoms lasted for about an hour after the test. Even at high air velocities there were no beneficial effects from the rapidly moving air at this temperature. One can readily understand why some subjects collapse when the thermometer registers 98° in the shade. All subjects agreed that but little work can be done at a temperature of 100° F. If the subjects had remained at this temperature for one full hour, they were positive that absolutely no work could have been done at the expiration of the time. Electric fans, therefore, although of value in temperatures up to 95° (which heat we seldom experience), would have very little beneficial effect if the air surrounding us were maintained at 100° F.

Luminous Water Signs

(*Continued from page* 452)

part has been bent into a sinuous form, as shown in the illustration. Above the bent tube another tube puts it in communication with the atmosphere, so that air enters being aspirated by the liquid drops, on exactly the principle used in water air pumps. The liquid arriving at the base of the bent tube gathers itself together, and by capilliarity is attracted to the walls of the tube, and forms thus a little cylinder with a concave meniscus at each end, and imprisoning between itself and the adjoining cylinder a little bubble of air more or less voluminous. A siphoning effect is produced, and what we may term a string of beads, is already formed within the circle of the glass tube, and in the vertical tube following it, fall by their own weight, drawing with them the bubbles of air separated by the cylinders of water and keeping the whole progressively in motion. The formation of the current of water and air, is continuous; no matter how long and curved the tubes may be, the alternation of water and air in this beadlike formation persists. As the drops reach the outlet of the tube, they are permitted to escape into the waste pipe if they are ordinary water. If on the contrary, they are composed of any colored liquid, it would be waste to let them escape, so they are collected in a bottle if the apparatus is very small, or in a tank if the apparatus is large, and various arrangements can be made for raising the liquid back to the original level for distribution. A small pump actuated by hand is sufficient for quite large installations. An automatic pump operated electrically, is of course, superior.

These liquid drops circulating in the tubes properly bent, and of proper design to carry out the *motif*, if it may be so termed, are illuminated obliquely by concealed lights, either on one side or on both. The meniscus of the water beads on account of their form, act as concave mirrors and concentrate the light which strikes them from the right and the left, the impinging light producing luminous points, much more brilliantly illuminated than the liquid of the beads or the air of the bubbles separating them, and whose luminous effects change constantly on account of their continual movement, all of which, combined with their alternation of direction of motion in the different juxtaposed tubes, produces the effect of scintillation comparable to the refraction seen in the case of precious stones. There is another effect of the most curious order, the letters and design seem to take very varied movements and effects of deformation, of trembling, of rotating, etc.

The effect is sufficiently artistic for the process to be valuable for decoration as well as advertisement.

The general design of the advertisement, both luminous and other portions of it, must not be kept in use too long, or else it will become monotonous and cease to attract the public.

In the process which we have explained, the effect is due to the design. It is enough to replace the screen to obtain a completely new effect, which only takes a few minutes.

In some animated pictures it is possible to imitate jets of water, fountains in action, and waterfalls in the middle of picturesque country scenes. These designs can be indefinitely varied.

Finally, as a matter of some importance, the expense incidental to obtaining this effect of water in motion, is practically negligible.

The luminous sign of whatever description, whether animated or intermittent, such as has been used up to date, is exclusively adapted to the exterior of a store. It follows that this kind of sign will not attract the eyes of the passers-by, except around the store, while it is much more important to attract them to the objects which it contains, or to attract the attention of the persons detained by curiosity before the window.

Selenium Star Photometer

By LEWIS J. BOSS

(*Continued from page 461*)

In using the selenium photometer to determine the periods of unknown variable stars a comparison star is selected, which is as near to the color of the star under investigation as possible and which is also known to be of a permanent brilliancy.

Betelgeuse, the conspicuous reddish star in the upper part of the constellation of Orion, is one of the most interesting subjects upon which the selenium photometer has been put to work. This star, whose period has never been accurately determined, has been under observation since 1919, and records have been kept of all readings obtained. These have now been reduced to a common scale and the result plotted as shown in Fig. 5. Just above is shown a curve of the late Professor Barnard's naked eye comparisons of Betelgeuse with the star Aldebaran. In this curve note that the zero line is representative of the visual brightness of Aldebaran, or, as it is known to astronomers, $^{\alpha}$ Tauri. All deviations above or below this line indicates that Betelgeuse ($^{\alpha}$ Orionis was at the time shown so many tenths of a magnitude above or below $^{\alpha}$ Tauri). The star is then the comparison star. It is particularly fortunate that this star was used as a comparison star in the curve shown, since the same one was used as a standard for the selenium photometer. In the lower curve the abscissae are the millimeters of galvanometer deflection produced by the varying light of $^{\alpha}$ Orionis being impressed upon the sensitive selenium cell. The ordinates are in this case, as in the curve above, representative of elapsed time. The full line extending completely across the graph at abscissa 15.25 is the deflection produced by the standard star, $^{\alpha}$ Tauri. Deviations above or below this line indicate, just as in the curve above, brilliancies greater or less than that of the comparison star. From a careful study of the two curves it appears as though the selenium photometer was about to realize the goal of the astrophysicist, that is, the possession of a device would depend wholly upon physical methods for the determination of stellar magnitudes.

Not only is the new photometer useful in observing stars known to be variable, but it will also undoubtedly prove to be of inestimable value in settling questions of debated variability (i. e.) whether the light of certain stars really does vary a small amount or whether they shine with a steady effulgence, as well as being useful in determining the periods of maximum and minimum brilliancy of that large class of variable stars, the irregular variables.

In the development of this method of investigation, the idea has been, primarily, to adapt a piece of apparatus to the measurement of variable stars, which apparatus would eliminate so far as possible some of the difficulties attendant upon other methods. In doing this care has been taken to consider the errors likely to occur and to eliminate them in so far as it is possible to do so. They have, at least in the present form, been reduced to a minimum. The precision attainable with the selenium photometer has not yet been prosecuted to its fullest extent, nor have enough numerical results been tabulated to indicate what additional contributions are to be expected from the use of this instrument in variable star photometry. A line of work most promising for workers with the selenium photometer is that of the study of the irregular variables of long period, many of which have never yet had a reliable period assigned to them. Such use will result in the addition of considerable information to the scanty knowledge now available concerning them.

Variable Stars

(*Continued from page 490*)

servations must be completed before the law governing them is recognizable. A typical star of Class 3 is Eta Argus, which is visible only from the southern hemisphere. In 1843 it blazed up until it rivaled the brilliant Sirius. Since that date it has confined itself to insignificant fluctuations which give the impression of the smouldering before the flame. Other examples are two stars in the northern hemisphere, one designated "R" in the constellation of the Shield, the other "R" in the Northern Crown. They fluctuate between fifth magnitude and utter invisibility through the most powerful telescopes. The spectra from maximum to minimum undergo radical changes seeming to indicate that the stars pass through tremendous physical transformations. Variables of Class 4 rise rapidly to maximum, where they halt, then return to minimum. Others experience several minima during a light cycle, the brightest of which is called the primary and the others secondary. (See illustration 1, Fig. B.) The periods are often extremely short, in several cases being only a fraction of a day. It is not an unusual occurrence for a star to double its light in ten minutes.

Scientists are always delighted to state definitely the cause of abstruse phenomena. A discussion of the first four classes of variables must necessarily deal in speculation but the Class 5 variables are no longer a mystery. The discovery of the forces which operate the fluctuations of these stars is one of the greatest triumphs of man's mind. Algol, which is the best known example of the type, remains at maximum, second magnitude, most of the time; loses 5/6 of its light in 4½ hours; remains at minimum 20 minutes; returns to maximum in 3½ hours. (See illustration 3.) The cause is simple. The spectroscope shows that a darker body revolves around Algol and periodically eclipses its light. The companion has never been seen; yet astronomers state with confidence that it is 840,000 miles in diameter, and is separated from Algol by a distance of 3,250,000 miles. Algol is 1,160,000 miles in diameter. The combined mass and the density of the system are respectively 2/3 and 1/5 of our sun's. The discovery of Algol's companion gave the clue to the existence of the black stars, "which fling unseen through the vast reaches of sidereal space."

Star Clusters

By BASIL NEWCOMB

(*Continued from page 438*)

Such are Orion, the Scorpion, the Big Bear. Somewhat more condensed, and also actual clusters, are the Hyades and the Pleiades; and from them we can go by gradual steps to the globular clusters, such as Messier 22 which is shown in the accompanying photograph, and to even more highly condensed systems like the great cluster in Hercules.

Messier 22, at a distance of 27,000 light-years from the earth, is a globular or slightly flattened system containing perhaps fifty thousand stars. The diameter of the cluster is more than three hundred and fifty light-years. A comparison with regions in the neighborhood of the sun shows that the stars of Messier 22, all of them so-called giants, are much more closely packed in their region of space than are the stars near the sun, as a glance at the accompanying photograph would lead one to suspect. In globular clusters there are hundreds of stars in the amount of space which near the sun contains but one.

Tantalum—All About It

By O. IVAN LEE, B. Sc.

(*Continued from page 447*)

be dissolved from a tantalum cathode leaving it unaffected. Caustic alkali solutions and in general all water solutions of chemicals (with the single exception noted above) are without action upon it, so that it is acknowledged the most resistant of all metals to wet corrosion.

One of the earliest uses to which commercial tantalum was applied was in the production of electric lamps, and apropos of this, one should note the great ductility of the material. A bar of tantalum as thick as the finger may be drawn into fine wire for filaments without heat treatment during the process. The strength of wire thus made is more than that of copper, nickel or platinum, but less than that of molybdenum and tungsten.

Since tantalum expands at nearly the same rate as platinum, like that metal, too, it may be sealed into glass. This property, of course, is very useful when it is necessary to lead an electric current into a glass vessel.

THE UNIQUE ELECTRICAL ATTRIBUTES OF TANTALUM

To begin with, the electrical resistance of tantalum is about eight times that of copper and about three times that of tungsten. This, however, though interesting, is not likely to cause it to displace cheaper materials already in use. It is the unique characteristics of a new material that set inventors to work to apply them to useful purposes.

Since tantalum when heated, eagerly combines with the common gases oxygen, hydrogen and even inert nitrogen, this very obstacle besetting the preparation of the metal becomes a most valuable property when, for example, tantalum is heated in a vacuum tube such as is used in the radio telephone. Thus it may be made to maintain a balance of residual gas suitable to the best conditions for transmitting or receiving. It is, however, the peculiar valve properties of tantalum which hold forth great promise of possibilities in applied electricity.

Suppose two polished sheets of tantalum are immersed in sulphuric acid of the strength used in storage batteries, and connected with a battery circuit of 75 volts. For an instant the current flows as with any ordinary metal, and then it suddenly trails off to a minute fraction of the original value—perhaps the thousandth of an ampere. Simultaneosuly, a rainbow film covers that piece by which the current enters the acid.

If now a plate of lead is substituted for one of tantalum, and the cell connected to an *alternating* current of the usual frequency, the current flow in one direction will very nearly be suppressed, resulting in a *pulsating direct* current. Part of the electrical energy is expended in electrolytic decomposition of the water into hydrogen and oxygen, the former appearing at the tantalum electrode while the latter is evolved at the lead. The current thus derived may be used to charge a storage battery, for electroplating or any similar purpose.

It is even possible by using two tantalum electrodes, so to rectify an alternating current that both halves of the waves are made to pass in the same direction, and then manipulated finally to become a smooth unidirectional current.

The leakage of electric tantalum valves varies under the conditions of the apparatus utilized, voltage, nature of electrolyte, current density, etc., but by reason of the great inertness of tantalum towards chemical solution of all kinds, *the electrodes of this marvelous metal are practically indestructible.* This is not the case, however, with valve apparatus constructed of aluminum or magnesium which, although capable of rectifying, soon disintegrate from chemical action. The efficiency of a unit for charging an ordinary storage battery is in the neighborhood of 33⅓%, comparing favorably with other types of rectifiers.

The tantalum rectifier is noiseless, devoid of moving parts and needs no attention except occasional replenishment of water.

THE FUTURE OF TANTALUM

It has been stated by Mr. Wells that "scientific prophecy will not be fortune-telling, whatever else it may be," so that it is with a feeling of considerable reluctance that one ventures to make any predictions concerning the probabilities of a metal so new to us as tantalum. It is, however, a strange and significant but consoling fact, that the useful metals seem to occur with an abundance nicely adjusted to the demands made upon them. A world in which mercury was worth as much as iridium (of which we have scarcely enough to tip our fountain pens), would be unthinkable, but at 90c per pound there is no complaint. Russia's single experiment in platinum coinage demonstrated again the folly of any metal save gold as a monetary standard. Soon after vanadium created an insistent demand for itself, a providential hoard created by some freak of geology was uncovered at a height of three miles in the Peruvian Andes. About the time that the advantages of zirconium oxide were appreciated, thirty ton boulders of it were discovered lying ready to move on the highlands of Brazil.

SUMMARY SUGGESTIVE OF THE DIVERSE POSSIBLE APPLICATIONS OF TANTALUM

Mechanical

Pen (nibs): elastic, hard, non-rusting.

Watch and Clock Springs: By alloying with carbon, silicon, boron, aluminum, tin, titanium.

Tools: Such as anvils where points and surfaces are subject to mechanical wear. Case hardening may be obtained by addition of oxide, aluminum, titanium, tin, silicon.

Cutting Tools: Knives, etc.

Dental Purposes: Pins for Teeth, instruments, non-rusting, can be sterilized, sharpened, possess hardness equal to agate.

Surgical Instruments: Non-rusting, can be sterilized, sharpened, possess hardness equal to agate.

Jewelry: With gold or copper, an alloy having appearance of gold but harder and more elastic.

Steel Industry: Alloy with iron, tungsten, molybdenum.

Alloys: With molybdenum as substitute for platinum; with tantalum 10, nickel 10, iron 80—tough, elastic, hard; with silicon (1-10%), an alloy of great hardness.

Chemical

Colors: Olive green and orange pigments were described and recommended in 1801 by Hatchett. It is the earliest recorded suggestion for the utilization of tantalum—(columbium.)

Refractory: Tantalum oxide is well adapted for withstanding high temperatures.

Standard Weights: Permanent, hard, economical.

Platinum Substitute: Cheaper, in some respects superior and releases platinum for indispensable purposes.

Chemical Apparatus: Crucibles, dishes, etc. Ideal if not subjected to too high a temperature.

Chemical Manufacture: Of sulphuric acid, replacing platinum for sprayers in the acid chambers; possess great durability.

Alloy: Of zircon 6.8%, columbium 53.5%, tantalum 39.7%, not attacked by any acid; can be heated to whiteness without oxidation.

Electrical

Filament: For incandescent electric lamp.

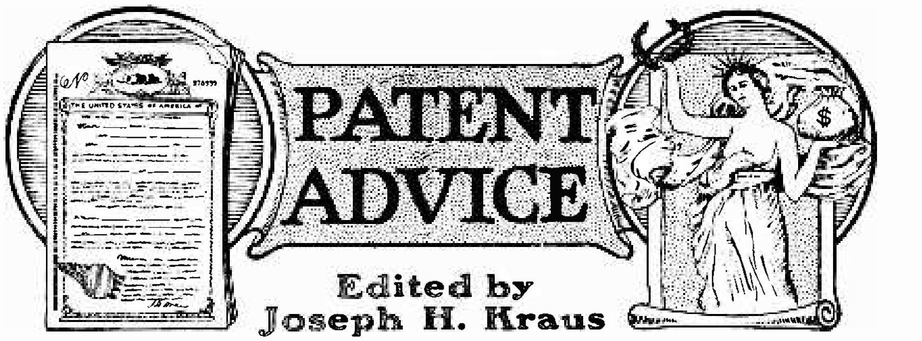
Wire: For electric heaters and resistance furnaces; for current leads into glass bulbs.

Sheet and Gauze: For radio tubes, X-ray tubes, electrolytic detectors, lightning arresters.

Plates: For electrolytic condensers, valves and rectifiers, anodes and cathodes for deposition of metals such as silver, copper, gold, platinum, nickel, antimony and especially zinc and cadmium with which tantalum does not alloy. Has advantage over platinum of greater rigidity, lower density and cost and allows of all metals plated being removed by treatment in acids.

Magnetic Alloy.

Non-magnetic Alloy: With nickel.



In this Department we publish such matter as is of interest to inventors and particularly to those who are in doubt as to certain Patent Phases. Regular inquiries addressed to "Patent Advice" cannot be answered by mail free of charge. Such inquiries are published here for the benefit of all readers. If the idea is thought to be of importance, we make it a rule not to divulge all details, in order to protect the inventor as far as it is possible to do so.

Should advice be desired by mail a nominal charge of $1.00 is made for each question. Sketches and descriptions must be clear and explicit. Only one side of sheet should be written on.

NOTE:—Before mailing your letter to this department, see to it that your name and address are upon the letter and envelope as well. Many letters are returned to us because either the name of the inquirer or his address is incorrectly given.

CARBIDE GAS ENGINE

(727) Robert Smith, Plentywood, Mont., asks for patent advice on a gasoline engine using carbide gas for the exploding agent.

A. There is no reason why carbide gas could not be used in automobile engines to run them, neither is there any reason to presuppose that any other inflammable gas will not explode when mixed with air or oxygen. Inasmuch as you have not changed the construction of the internal combustion engine in order to make it operate with carbide in any detail, we doubt if you could patent the use of a particular kind of gas in connection with the engine. We disagree with you as to the efficiency and economy of this system. Carbide gas is more expensive in its practical results than gasoline, and except for starting motors on cold days, its use would be undesirable.

We would suggest that you work along this line, namely, that you design a carbide gas generator which will supply gas to the engine when the same is cold, so that it can be started much more easily. Then the carbide gas flow should be stopped and gasoline be supplied in the usual manner. Some system whereby just a few drops of water will fall on the granules of the carbide, to give enough gas to start the engine only, would be most feasible.

BATTLE PLANE

(728) Constant A. Shilcoski, Detroit, Mich., desires to patent an airplane in which machine guns are mounted at the ends of the wing structures, operators being located there.

A. Do you not think that the world has had enough of war for the time being to satisfy it for at least twenty or thirty years? If so, then naturally, it would be absurd to suggest applying for a patent for your device. There probably will be no more war for at least twenty years—consequently any war inventions, or any war suggestions, are worthless, and at the end of the seventeen year period would afford no protection to the inventor. Even then, equipping your airplane with two machine guns, on port and starboard, in special housings, which guns are free to move in any direction, necessarily means that the operators of the machine-guns cannot operate the plane. Consequently, when a plane of this nature is sent crashing to earth, there is a loss of five lives instead of one, or at the most, two. Firing the guns is not more directive or effective, and maneuvering an airplane with heavy bodies at the ends of the wing structure is more difficult while the speed of the airplane is decreased because of added wind resistance. We would not suggest attempting to patent this idea, nor any other war idea, unless of extreme importance.

FIRE DETECTOR

(729) Geo. J. Frankovich, Anaconda, Montana, asks whether he should patent a fire alarm system, in which a fuse is laid throughout the building communicating with an explosively operated switch, the fuse being of the type used for blasting purposes.

A. We most strenuously advise against attempting to patent such a device. In the first place, the setting off of the fuse requires that a flame come in actual contact with said fuse. This means that the fire will necessarily have had obtained considerable headway, which fire could be further spread by the burning fuse. The device is also impractical because of the fact that an explosive is used in actuating the mechanism of the same. Explosives cannot be sent out in the mails, making the devices useless for out-of-town buyers (unless express packages were sent). The resetting of the instrument likewise is quite expensive, when one considers the amount of fuse which has to be laid after each conflagration. We are positive that insurance and fire underwriters would not sanction this method, which, rather than being a detector of fires, would positively lead to complete combustion. Many other drawbacks will present themselves if you but think along any such lines.

SPARK GAP

(730) Eugene Feinberg, Fort Smith, Ark., asks whether he should patent a spark gap for radio purposes, a diagram of which he sent.

A. Without a doubt your device can be patented, but what will be the use? Today an open spark gap is not employed for radio but principally for automobiles and naturally experimental purposes. A patent upon your system with reference to its experimental value, would hardly be worth the expense. Within another year or two radio spark gaps together with much other trash with which radio was and is today infested will be relegated to the junk pile. All of these devices make historical material for readers interested in radio's romance. But to attempt to patent devices to be placed in the ranks of such historical works would be the height of folly. We, therefore, advise most strongly against attempting to secure a patent upon this scheme.

A LEGAL QUESTION

(731) Alfred First, Dongan Hills, New York, asks what could happen if he infringes upon a patent.

A. We do not profess to be legal experts. Questions such as this could only be definitely decided after the suit has been settled. However, this may occur:

If you infringe upon a patented article, and a suit is brought against you and the action is won, anything which you have or which may be coming to you as a result of this infringement, may be attached and all your personal belongings and properties with the exception of about $250.00 worth of property, real and personal, may be claimed by the concern who won the suit. Any money or moneys which you may have put into the manufacture, sale or exploitation of your device could be attached, and subsequent returns would come into the hands of the winner of the suit. The court then may enjoin you from manufacturing this device, and should you fail to heed the warning, a jail sentence is apt to follow.

Dr. Hackensaw's Secrets

By Clement Fezandié

(*Continued from page* 436)

to whether space is a vacuum, or is filled with ether or with highly rarefied air or other gas, no balloon could ascend very high in it, as the density diminishes as we ascend. Hydrogen, the lightest gas known, would not carry us very far. Even if we were able to make a vacuum balloon, with concentric envelopes strong enough to resist crushing from the atmosphere, and if we dropped off one shell after another as we ascended, this balloon would have to be so large, to rise even a few hundred miles, that it would be impracticable to build it."

"Why so? A balloon, with no gas inside, ought to be very light."

"True, but at a height of one thousand miles above the earth, our atmosphere must be so rarefied that it would probably take thousands of cubic miles of it to weigh a pound. Consequently the problem would be to build a balloon thousands of miles long and weighing less than one pound. This would be a manifest absurdity. So we may dismiss the idea of a balloon as a means of traveling to the moon or to the planets."

"What is your opinion about the possibility of screening a body from the effects of gravitation. H. G. Wells uses this method for sending his first men to the moon. He places them in a car that is surrounded by shutters, which, when closed, are impervious to the attraction. By opening the shutter in the direction in which he wishes to go, the passenger lets in the attraction of the earth or the moon and the car starts off in the desired direction. When his speed becomes too great, he lets in a little counter-attraction from the opposite side, and so can regulate his speed and direction at will. What do you say to that idea?"

"The idea is certainly ingenious," observed Doctor Hackensaw with a smile, "but it is open to the objection that we have as yet found no means of shutting off gravitation, nor have we any data to lead us to believe that gravitation can be shut off. Of course, as yet, we do not know what gravitation is. Several unsatisfactory metaphysical theories have been advanced, but none of them satisfies me. As for myself, I cannot even make up my mind as to whether attraction is, as commonly believed, a pull between two bodies, or, what appears to me more probable, a push exerted on the two bodies from outer space, forcing them closer together. Analogy, however, would lead me to believe that gravitation, like heat, light, sound, electricity, &c., is merely 'a mode of motion,' as the physicists call it—in other words a vibration. The whole subject is as yet in complete darkness, but, as I observed at the beginning, I have discovered no new force and no new method of controlling the forces already known to man. I am relying entirely on old and well-known forces to carry me to the moon.'

Silas Rockett was puzzled. He had apparently exhausted his entire arsenal. He tried one more shot, however.

"Is it possible that you are thinking of using atomic force?"

Doctor Hackensaw shook his head. "No," said he. "I shall not use atomic forces."

"Nor radio-active force? You will not propel your car by means of wireless waves?"

"No indeed, our electrical knowledge at the present day is insufficient for any such schemes."

"Then I give it up," said Silas. I have read somewhere that, if the earth were twenty-four times its present diameter, bodies at the equator would be traveling

(*Continued on page* 504)

Answers to Scientific Problems and Puzzles

(*Continued from page 456*)

THE HUMAN SAMPSOM

If the stone weighs but a few times as much as the hammer the feat here described would be impossible, but if it exceeds the weight of the hammer many times, the inertia of the stone will prevent it from responding quickly to the blow and most of the energy of the stroke will be dissipated on the rock without affecting the man's head at all. The most difficult part of the performance is to support the stone—not to withstand the blow.

THE ENCHANTED RING

The results can be obtained by hiding a powerful electro-magnet within the figure of the man, connection being made to a source of alternating current. As the visitor approaches the figure to crown it with the ring, the magician steps on a contact maker concealed by the carpet and thus energizes the magnet. The alternating field of the magnet induces alternating eddy currents in the ring, and, as the very nature of eddy currents is to oppose the action by which they are produced, repulsion results between the ring and the magnet. The eddy currents are also responsible for the heating of the ring.

CALIBRATING A HYDROMETER

Since the hydrometer weighs 20 grams, it will displace 20 grams of any liquid in which it floats. At the level at which it floats in water it will displace 20 cubic centimeters because each cubic centimeter of water weighs a gram. At any other level, say for a liquid of density D, it will displace 20/D cc. Between the points marked "1" for water and "D" for some other liquid the stem must displace $(20 - 20/D)$ cc. But this volume is also $0.25x$ where x is the distance in centimeters between the points "1" and "D." Hence $0.25x = (20 - 20/D)$, or $x = 80\ (1 - 1/D)$.

ANOTHER PULLEY SYSTEM

Let X represent the force with which the man has to pull to maintain himself in equilibrium. Then the force on rope A will likewise be x pounds and the tension on each of the ropes B and C will be $2x$ pounds. But since the two ropes B and C together support the entire weight of 240 pounds we have that $4x = 240$, or $x = 60$ pounds.

WAXING OR WANING?

The phases of the moon are, of course, due to the relative position of earth, moon and sun, which constantly changes as the moon revolves eastward in its orbit around the earth. If the moon is on that side of its orbit in which it approaches the sun it is evident that we will see progressively less and less of the illuminated surface of the moon until when the moon is almost between us and the sun we cannot see it at all. With the moon in this part of its orbit, we have, then, a waning moon. We also have a moon with its illuminated surface toward the east. But when the moon is moving away from the sun on the other side of its orbit we see progressively more and more of the illuminated surface and hence have a waxing moon with the illuminated surface now toward the west.

RAY TREATMENT FOR LUNGS

Rafael Santos, a 25-year old medical student in the University of Paris, declares he has discovered an infallible cure for tuberculosis.

After three years of experimenting at the leading hospitals, he has constructed a set of lenses for introducing ultra-violet rays into the human lungs. He declares that his experiments proved that these rays will kill all tuberculosis bacilli in less than half an hour.

Dr. Hackensaw's Secrets

(*Continued from page* 502)

seven miles per second and hence would be hurled off into space. Have you found means of swelling out the earth to twenty-four times its present size?"

Doctor Hackensaw gave vent to a hearty peal of laughter. "No," said he, "I shan't attempt to give the poor old earth a fit of the dropsy. Nor shall I attempt to build a mountain or tower at the equator, of the required height. Let me see. The radius of the earth is four thousand miles, so my mountain would have to be 96,000 miles high! I'm afraid I couldn't find a contractor willing to undertake the work, nor would there be materials enough to complete it. But you are learning, Silas; you are getting nearer and nearer to the correct solution. It *is* centrifugal force that I shall use, but not the centrifugal force of the earth itself."

"What then?"

DR. HACKENSAW EXPLAINS HIS SCHEME

"Well, Silas, the problem is this. I must find means of giving my car a speed of about seven miles per second, and yet I must start the car gradually in order not to harm the passengers. Evidently the solution is to start the car slowly and keep it going more and more rapidly until it has acquired the necessary velocity, and then launch it off into space. In this way my passengers will suffer scarcely any inconvenience. There will be no shock at starting."

"I begin to see."

"Yes, the solution is obvious. What I need is a large revolving wheel like a Ferris-Wheel, with the car fastened to the end of one of the spokes. The wheel can be started very slowly and its speed gradually increased until the required velocity is attained, and then, at the proper moment, the car can be released and shot off into space. In this way there will not be the slightest shock for the passengers. But why am I jabbering away here? I have kept the affair secret so far, but I am soon to make it public. Come along with me and you can see the machine for yourself. It is all completed, save for a few final tests to make sure that everything is in good working order."

Luna City was the name which Doctor Hackensaw had given to the secluded spot which he had chosen as the launching-place of his car for the moon. For miles before arriving at the place, Silas Rockitt was eagerly scanning the horizon for the gigantic wheel which he firmly expected to see. His disappointment may be imagined therefore when, on arriving at the spot, he found that the apparatus was no larger than an ordinary Ferris-Wheel.

CENTRIFUGAL FORCE FROM SPINNING WHEEL HURLS CAR MOON-WARD

"What!" he cried in a tone of disgust. "Is it that little toy-wheel that is going to shoot your car to the moon!"

"Yes Silas—at least if my calculations are correct. Please notice that the framework, which supports the wheel, has its foundations in the solid granite beneath. In fact holes have been drilled deep into the rock, and the whole frame-work has been solidly tied down by means of powerful chains. This is not only to prevent wobbling, but to ensure that the wheel itself will not be carried away as well as the car."

"But that wheel seems only thirty feet in diameter!" said Silas. "Each revolution would be only about one hundred feet. To get a speed of seven miles per

(*Continued on page* 514)

Around the Universe

By RAY CUMMINGS

(*Continued from page 435*)

announced, "I got to have all the dope in my head."

Sir Isaac had frequently been tracing their flight upon a celestial map of his own making, and Tubby now demanded to see it. Sir Isaac produced it readily, from the table drawer, and clearing a space on the table, unrolled it before them. By the light of an electric bulb—for the side and floor windows admitted nothing but starlight—Tubby examined it.

"This is merely a rough drawing I made myself," Sir Isaac explained apologetically. "It shows the solar system—though not at all to scale—and gives a rough idea of the present positions of the planets, and our course up to date."

This is what Tubby saw:

"You notice," said Sir Isaac, indicating with his pencil point, "that the Sun occupies the center of the solar system, and the planets revolve around it in concentric rings which are called orbits. These are not circles, but are ellipses—so that the Sun is not exactly in the center, but a little off to one side—in one of the foci of the ellipse, to be technical. Thus the orbit is somewhat nearer the Sun in one portion and further away in another. The amount of this difference is called the eccentricity of the orbit."

Tubby nodded his comprehension; Sir Isaac went on:

"Fortunately, as you observe, all the planets chance to be on this side the Sun just now. . . . I must alter our course toward Jupiter. We are now headed for Venus, but Jupiter, you see, is considerably further along in his orbit."

Sir Isaac went to the keyboard, and a moment later Venus, as seen through the lower windows, swung sidewise out of sight. A new region of gleaming stars—none of unusual brightness—came into view.

"I am heading well past Jupiter," said Sir Isaac. "We are falling diagonally sidewise now, *forward* by the combined attraction of all those stars, and *sidewise* by the repulsion of Venus and the Earth and all the stars behind them. This will bring us into a direct line drawn from the Sun to Jupiter—and then I can make better speed by using the Sun's repulsion and Jupiter's attraction combined, which I cannot do now."

By careful consulting of the chart, Tubby finally got this clear.

"It's a longer route," Sir Isaac added. "But I think it will prove quicker. . . . You'd better lie down, Tubby—you're tired out."

Tubby was indeed terribly sleepy—but, unselfishly he realized that Sir Isaac must be also.

"I'll watch," he said. "*You* take a nap."

But Sir Isaac wished to get the vehicle upon its direct course first.

"We'll be in line with the Sun and Jupiter in about two hours," he explained. "I'll call you then. From then on we will hold the same course all the way."

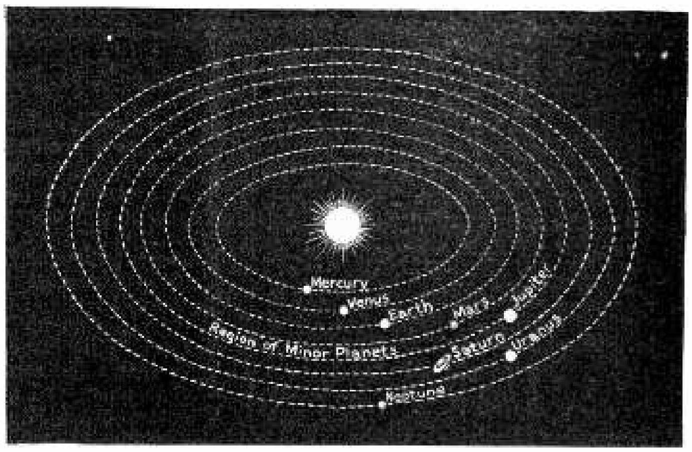
Tubby yielded, and started upstairs. Then, remembering Ameena, he went into the store-room instead, and with the cushions from one of the chairs of the instrument room for pillows, stretched out on the floor and went to sleep promptly.

* * *

"Wake up," said Sir Isaac, shaking him. "It's seven forty—you've been asleep nearly four hours."

Tubby rubbed his eyes, and clambered to his feet. "What's doin'? Anything new? Where are we?"

"We're on our direct course to Jupiter now," Sir Isaac answered. He had shaved and washed. His hair was slicked back and he was smoking a cigar; but his face was haggard and he looked tired out.



Sir Isaac's Sketch Giving a Rough Idea of the Positions of the Planets.

"You can take charge now," he added. "I must get some sleep, if only for a few hours."

Tubby sat alone on a cushion at the floor window of the instrument room. The Sun, from which they were now receding, as Sir Isaac had told him, at a velocity of 15½ million miles an hour, was blazing high over the roof of the vehicle, and thus was invisible from the starlit room downstairs. Through the floor window Tubby could see nothing but gleaming silver stars. One of them, he could not distinguish which, was Jupiter.

Tubby whistled to keep himself awake. After an interval he looked at the chronometer. It was 8.20 A. M. Why didn't Ameena wake up? Tubby was lonesome and depressed. A little later he went into the kitchen and made himself a cup of coffee. Again he wished fervently Ameena would come down and join him. Should he wake her up? Wasn't it time for breakfast? Wouldn't she ever come down?

For another hour he wandered disconsolately about the lower rooms, glancing at intervals through the floor windows to make sure no derelicts were in sight. Remembering Sir Isaac's jaunty appearance, he shaved and washed—fortunately having had the forethought, the night before, to rescue his razor from the bedroom upstairs.

He had about decided in desperation to awaken the girl, when, on an impulse he climbed into the little dome on the roof where Sir Isaac had mounted a small telescope. A moment later he was clattering down through the vehicle, bellowing loudly for Sir Isaac and Ameena.

THE SKY TRAVELERS ARE FOLLOWED

"Hey, perfessor! Ameena! Oh, Ameena! Get up, quick! There's somethin' follerin' us!"

Sir Isaac came bounding upstairs from the store room, meeting Tubby in the upper hallway. From one of the bedrooms came Ameena's sleepy voice:

"What *is* it? *Must* I get up?"

Together the two men rushed up into the little observatory. Another vehicle, twice as large as their own and somewhat different in shape, hovered almost directly above them, showing as a dark spot in the firmament and edged with silver from the Sun's rays behind it.

"That Mercurian girl!" Sir Isaac gasped, with sudden memory. "She flew to the Twilight Country! She said she was going to have revenge!"

They were indeed, being followed! This pursuing enemy was at that moment hardly more than five miles away, and was overtaking them rapidly!

CHAPTER VI

IN WHICH THE VOYAGERS PASS MARS, DODGE THE MINOR PLANETS AND INTERVIEW HIS SUPREME HIGHNESS THE GREAT MOGUL OF JUPITER

Sir Isaac dashed back to the instrument room three steps at a time, with Tubby at his heels. Ameena came from her room and followed them.

"What is it?" the girl demanded. "Is something wrong?"

Tubby called back over his shoulder:

"Them Mercurians is after us. Right overhead—comin' fast. Come on down—we got to do somethin'."

Sir Isaac rushed to the keyboard.

"Switch our course," Tubby suggested. "Let's see if they can turn when we do. . . . Or how about goin' faster? Can we go faster?"

"Wait," commanded Sir Isaac. He depressed two keys—a black one on one bank and a white one on another—and raised the ones which had been down. Then he dashed away upstairs again.

Tubby had no more than time to compliment Ameena on her appearance—she was dressed quite as on the day before, but her face was flushed with excitement and her eyes sparkled, so that she was more beautiful than ever—when Sir Isaac was back. He sank into a chair and smiled at them weakly.

"That danger's past, for the moment. We have left them out of sight behind us."

"So quick?" exclaimed Tubby. "Out of sight already? We must be goin' some."

Ameena looked her relief. Sir Isaac made some further adjustments of the keys.

"I've just slowed us up again," he said. "I would not dare go as fast as we would very soon have been going."

"Well, how fast are we goin' the way you got it now?" Tubby persisted.

28 MILLION MILES PER HOUR

"About 28 million miles an hour," stated Sir Isaac. "Of course I haven't computed it yet—but I judge we shall shortly attain that velocity. I am now using six-sevenths of the Sun's repulsion with everything else in neutral. Our rate of speed depends very largely on the length of time allowed for acceleration, you understand."

He gazed down through the lower window anxiously, and muttered:

"Heavens, I do hope nothing gets in our way!"

"Maybe we better slow up," Tubby suggested. It did seem a trifle fast to be going, when he came to think of it. On the other hand such a speed was not in the least beyond his understanding now. Sir Isaac had already explained something of the laws governing freely falling bodies; and Tubby had recalled that old stunt of dropping a baseball from the top of the Washington Monument, which fell so fast even in that little distance that even professional catchers could hardly catch it. The vehicle was more than a freely falling body—it was being *pushed* downward.

Sir Isaac shook his head at Tubby's suggestion that they slow up a bit.

"We must chance the danger," he said, though not without considerable perturbation. "That Mercurian vehicle may be able to attain this speed also—or even a greater one. We cannot tell."

"Suppose they *should* overtake us," Ameena speculated. "They could not board us—or collide with us without death to themselves?"

"They might have some means of destroying us—*I* do not know," Sir Isaac replied. "Though possibly the Light-ray is useless in Space." His voice became meditative. "Curious I never thought of *that* before. I suppose it *would* be inoperative."

"*I* think," said Ameena, "that they are merely trying to reach Jupiter before us. Perhaps they want to warn the Jovians against us. To persuade them not to—"

"Meaning——" Sir Isaac interrupted eagerly. The poor man's mind was working so constantly that he seemed grateful to anyone who would do his thinking for him.

Ameena finished:

"Meaning that I think it shows that on Jupiter the rulers are at least neutral."

"Sure," exclaimed Tubby. "You're some clever girl, Ameena. If them Jovians was our enemies, these Mercurian guys wouldn't bother chasin' us there. They'd know we'd get walloped anyhow. You got the right idea, kid." He gazed admiringly at Ameena, and the Venus-girl blushed charmingly.

This conclusion, thus happily arrived at, cheered the three adventurers immeasurably. They now felt tolerably certain of at least a square deal on Jupiter—if only they could arrive there ahead of the enemy.

"Well, that bein' settled," declared Tubby, rising. "Let's eat."

On this flight outward from the Sun they had crossed the orbit of Venus about 6.30 A. M., while Tubby and Ameena were asleep—though this course to Jupiter took them many million miles ahead of Venus' position in her orbit. This Tubby and Ameena readily understood by another glance at Sir Isaac's drawing, which they consulted soon after breakfast.

About 8.15 A. M., while Tubby had been on watch alone, they had crossed the orbit of the Earth—though nearly twice as far then from the Earth as they had been from Venus.

"Mars revolves around the Sun at a mean distance of 141,701,000 miles," said Sir Isaac, some little time after breakfast. "We should have intersected his orbit about 10.40 A. M.—that was when we were closest to him."

"An' you didn't tell us!" cried Tubby reprovingly. "I want to get a look at that—that murderin' villain."

It was then about ten minutes of eleven. Mars, to which they had passed comparatively close, still showed as a half-lighted, circular, reddish disc. Its tracings of fine intersecting lines—the "canals"—were quite distinguishable.

Even at the enormous velocity the vehicle had now attained, all the heavenly bodies hung apparently motionless in the firmament—except Mars, which because of its nearness, seemed slowly moving upwards as the vehicle dropped past it.

Tubby, standing at the side window, shook his fist at the disturber of the peace of the Solar System.

"We'll fix you yet—you——"

meena laughingly pulled him away.

"Is Mars as large as my Venus?" she asked Sir Isaac. "Or your Earth?"

"The diameter of Mars is 4,316 miles," said Sir Isaac. "The Earth is 7,917 and Venus 7,629."

"Only a little guy!" Tubby was contemptuous. "That's the way with them little fellers—Mercury too—always lookin' for a scrap."

Sir Isaac went on:

"Mars revolves around the Sun once in a little less than 687 days. That is the length of his year. His orbital speed is 15 miles per second. He is ahead of the Earth now in his orbit, but the Earth travels forward at the rate of 18½ miles per second. Thus you see, the Earth is overhauling Mars—and when they are both in line with the Sun, that will be opposition. That's their closest point to each other until the Earth comes around again—and that's when the Martians will attack."

Poor Sir Isaac, from one threatened catastrophe or another, had had so far very little sleep since leaving the Earth two days before. About half past eleven that morning Tubby and Ameena sent him to bed again.

"Don't let me sleep more than two hours at the most," he said anxiously. "There are thousands of Minor Planets in here between Mars and Jupiter."

"Shucks," disclaimed Tubby. "That don't make no difference. Ain't *I* on guard?"

It was a magnificent chance for sarcasm, but the sterling character of Sir Isaac forbade such weakness. All he said was:

"Our velocity of 28,000,000 miles an hour would be sufficient to carry us from Earth to Venus, or from Venus to Mercury in a little over sixty minutes! I don't want you to forget how fast we are falling now."

With which admonition he retired.

It was a long, tiresome, comparatively uneventful day—at least it would have been, if Tubby had not had Ameena's companionship. She sang to him again; and with his somewhat raucous tenor voice they contrived "Inter-planetary duets" as Sir Isaac jocularly called them. When they had tired of music they climbed into the dome to make sure their pursuers had not again come into sight. The overhead sky, out of which they were falling, showed nothing unusual. Mars—well above them now—had dwindled to a small, reddish star; the Earth, Venus and Mercury were indistinguishable among the mass of other glittering worlds.

"Look at the Sun," said Tubby. He pulled Ameena toward him. He had indeed, progressed to where his arm was almost constantly about her, which, since youth and love are the same the Universe over, Ameena accepted as quite reasonable and natural.

"Ain't the Sun gettin' little?" Tubby added.

The orb of day had dwindled to half its apparent size as viewed from Earth. The vehicle too, was growing hourly colder. Ameena shivered a little.

"Come on down," said Tubby solicitiously. "We'll have to get the perfessor to heat the place up more—an' get you dressed warmer." His appreciative glance swept Ameena's dainty figure. "I'll see what I can dig you up—right after lunch. Come on down where it's warmer—let's play cards."

Explaining to the girl the intricacies of the fifty-two different cards of the deck took nearly another hour, after which Tubby's stomach peremptorily informed him that it was time for lunch. He swept up the cards, and with sudden thought gazed anxiously down through the lower window to see if they were about to collide with anything. Jupiter had grown to a marvellously brilliant star; beyond that, everything was as before.

"You go fix up somethin' to eat," he said to the girl. "I'll call the perfessor—he's asleep long enough anyway."

Sir Isaac came down shortly, dressed in a warm-looking tweed suit with golf trousers. Glancing at the chronometer, he immediately plunged into an intricate mathematical calculation.

"Our velocity since 9.30 this morning has averaged just 28,502,122 miles an hour," he announced a little later. "My guess was right."

"Good," said Tubby. "Come on into the dinin' room. Lunch is ready."

After lunch Tubby himself dressed more warmly—in a Norfolk jacket golf suit and heavy grey flannel shirt, an outfit that was extremely becoming. He then sent Ameena upstairs, magnanimously offering her anything and everything in the way of apparel she could find. She returned a few moments later, and stood shyly awaiting his approval. She had donned a heavy pair of golf stockings and rubber-soled shoes which miraculously were almost small enough for her. And over her knee-length white dress, she was wearing a natty-looking man's overcoat which almost swept the ground. Her hair was now piled on her head, with a huge, red-silk handkerchief bound around it.

Even Sir Isaac glanced up from his figures long enough to admire her appearance. She looked indeed, like a radiantly beautiful little Earth-girl, on her way to the beach for a swim.

"Fine," declared Tubby. "Keep that coat buttoned up an' you'll be nice an' warm."

They were now—it was about 2.30 P. M. —more than half-way in distance from Mercury to Jupiter, Sir Isaac announced.

"Tell us somethin' about Jupiter," said Ameena, sitting down beside Tubby and giving him her little hand to hold. "You said it was a very big Planet."

"It's mean diameter is 87,380 miles," Sir Isaac answered. "Its volume is 1390 times greater than the Earth!"

"Some big Planet," Tubby commented.

Sir Isaac added:

"And it makes one revolution around the Sun in 4332.5 days. Thus its year is equal to 11 years, 314.9 days on Earth."

"My goodness" said Tubby.

"But Jupiter's *day* is only about 9 hours and 56 seconds long. That is because it rotates on its axis so very swiftly."

Tubby interjected:

"This here Jupiter's a re-*mark*-able Planet, ain't it?"

"Go on," said Ameena. "Tell us more."

Sir Isaac seemed embarrassed. "Well to tell you the truth," he said hesitantly, "I don't really know very much about Jupiter. You see I've never really had occasion, up to now, to——"

"Right," interrupted Tubby. He had no wish to be hard on his friend, especially before a girl. "What's the difference? We'll soon be there an' see it for ourselves. . . . When *do* we land, perfessor?"

Sir Isaac looked worried again.

"At our present velocity I calculate we should enter the Jovian atmosphere about 10.15 P. M. tonight, but——"

"Very good, *in*-deed, perfessor."

"But I dare not maintain this velocity," Sir Isaac finished.

"Why not? Ain't we in a hurry?"

"We *are* in a hurry certainly," Sir Isaac conceded. "But, as you know, the more haste the less speed sometimes. We are now in the region of Minor Planets. More than eight hundred of these little worlds have been discovered and listed, even by those inefficient astronomers of Earth. *I* have never given the subject much attention—except in the case of 'Hector Servadac'—and in *that* story——"

"*We* ain't seen no Minor Planets yet," Tubby hastily interrupted.

Sir Isaac drew him and the girl to the side window.

"There are a dozen or so," he said simply.

Tubby made them out after a moment—very tiny half-moons gleaming among the stars. They were apparently moving upward as the vehicle fell past them, while all the stars appeared quite motionless.

"Some of these little worlds are only from a few hundred thousand to a million miles away from us," Sir Isaac added. "We could reach them with this velocity in a minute or two! They're all around us now—so you can understand what chances we're taking."

Tubby understood indeed; and when, a little later, he saw through the lower window a gleaming disc come into sight, grow to the size of the Moon, and sweep past them to one side and out of sight above them—all in the space of a minute—he was glad enough to have Sir Isaac reduce his speed. It gave the pursuing Mercurian vehicle a better chance to overtake them, of course but even that was the lesser of the two dangers.

The evening was a long one. Tubby and Sir Isaac played cards after dinner, with Ameena an interested spectator. They discussed their Mercurian pursuers a little—the other vehicle had not again appeared. Ameena retired about ten o'clock and Sir Isaac, shortly afterward, lay down at Tubby's feet on the floor of the instrument room.

Tubby faithfully kept watch until two in the morning. Jupiter was now considerably larger than the Moon appears from Earth—a silver disc with broad dark bands on it, and a huge red spot, like a dull red lantern gleaming from its lower hemisphere. The red spot winked and went out shortly after Tubby discovered it.

When Sir Isaac woke up, of his own accord, Tubby, too tired to ask any questions, fell asleep on the floor, wrapped up in a blanket from the vacant bed upstairs. He dreamed he was a railroad train and that Jupiter was flagging him with a red lantern. He wanted to stop, but couldn't. There was a terrible collision. . . .

Tubby opened his eyes to find Sir Isaac shaking him violently.

"All right," he protested, sitting up dizzily. "Lemme alone. What time is it? Ain't we there yet? Where's Ameena? "What's that red light comin' from?"

THE TRAVELERS APPROACH JUPITER

It was just six o'clock. A lurid red glare was shining up through the lower window. The room was frightfully hot! Tubby, as soon as he was fully awake, stared down through the heavy glass pane. The dark surface of Jupiter, over which they were poised, stretched out as far as he could see in every direction. Directly underneath the window, like the huge mouth of a red-hot furnace, yawned a gap in the Jovian atmosphere from which lurid tongues of flame were licking upward into Space—venomous, scarlet-red tongues thousands of miles in length.

Tubby was awed as well as alarmed. They were dropping directly into the mouth of Hell!

"Don't be frightened," laughed Sir Isaac from behind Tubby's shoulder. "We're two million miles up yet and falling only at the rate of half a million miles an hour. That is the great red spot of Jupiter. I've always wondered just what it was. Those are tongues of flaming hydrogen. It proves conclusively that Jupiter is more like the Sun than any other Planet. Its surface is not solid on this side, and, as you see, it is internally heated to a very considerable degree."

While Tubby gazed, fascinated, Sir Isaac went on enthusiastically:

"Jupiter is partially self-luminous, which I have also always believed. And, because of its internal heat, the surface temperature is easily warm enough to sustain life, even out here so remote from the Sun."

"That looks absolutely *too* hot to live in," Tubby declared, gazing down into the crater of this mammoth volcano.

Sir Isaac laughed again; evidently he was in high spirits at this complete verification of his theories.

"Of course it's too hot on *this* side. I knew that, but I came around here to see the red spot. We had to follow it around, you see, because of the Planet's very rapid axial rotation. The surface, as I said, isn't solid. Nevertheless, since we know that Jupiter *is* inhabited, however much it would appear *not* to be, there must be at least a small portion of solid surface. We'll go around to the other side again and locate it."

"Like lookin' for land when flyin' over the ocean?" Tubby illustrated.

"Exactly."

Tubby rose to his feet.

"Very good, perfessor. Very good, *indeed*. You navigate us around, an' I'll go wake up Ameena. She mustn't sleep *all* the time. We got to eat."

PASSING ONE OF JUPITER'S SATELLITES

They passed fairly close to Satellite IV, which revolves around its mother globe at a mean distance of 1,162,000 miles. They were then having breakfast, and during the remainder of the meal Sir Isaac entertained them with a most interesting dissertation on the nine satellites of Jupiter.

They were all three dressed as on the evening before, though Ameena had discarded the overcoat. She resumed it after breakfast, however, for when they had passed around over the other hemisphere of Jupiter, beyond the flames of the "red spot," exposed again to the cold of Inter-planetary Space and warmed only by a very small, pale little Sun, the interior of the vehicle rapidly cooled off.

After breakfast, an observation of Jupiter through the lower window showed only dense, black cloud masses.

"Let's go down, perfessor," Tubby suggested. "Can't see nothin' up here through them clouds." He added gloatingly:

"I guess we beat them Mercurians in, all right."

They entered the Jovian atmosphere about eight o'clock—at an altitude of 1,400 miles—

(Continued on page 513)

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Around the Universe

(*Continued from page 511*)

a depth of air strata that surprised even Sir Isaac. Inky blackness surrounded them for a time. At 110 miles they emerged into daylight. Later all the clouds swept away. The pale Sun shown through the side window, rising over the horizon—for it chanced to be early morning on this portion of the mighty Planet—shortly after dawn of a clear, frosty-looking Jovian day.

"Looks awful chilly out," Tubby remarked dubiously.

"Yes," agreed Sir Isaac. "We would be freezing in here now if it were not for our friction in passing through the atmosphere. I have shut off our heating apparatus. . . . It will be much warmer down below, however. The internal heat of Jupiter warms its lower stratas of air."

At an altitude of 25,000 feet they could distinguish quite plainly the Jovian landscape over which they were passing horizontally—a barren land that looked as though it might be thick black water and mud. It seemed to boil very sluggishly in spots. Here and there it appeared firmer—and there were curious vegetable growths as near like two hundred foot mushrooms as anything else Tubby could think of.

JOVIAN CITIES APPEAR

The landscape was changing constantly. Now they came over a barren, almost rocky land, with enormous trees like pines and cedars. Half an hour later the forests began occasionally to be dotted with cities—mammoth buildings rising in terraces two thousand feet into the air. . . . Everything seemed built on the same gigantic scale.

They selected, quite at random, one of the largest of the cities; and descended in an open space nearby. It was 9.50 A. M. when they came to rest upon the surface of Jupiter—a flight from Mercury, smallest major planet of the solar system, to Jupiter the largest, of exactly 34 hours and 5 minutes.

THE SKY PARTY MEET THE GREAT MOGUL

The audience with the Great Mogul of Jupiter—who came riding out of the city with his Wise Men on an enormous animal—like a queer-looking elephant with broad, very flat feet—took place about 12 o'clock noon Earth Eastern time, though it was by then late afternoon of the Jovian day.

It may seem remarkable that so great a dignitary would go to his visitors rather than bidding them come to him. The answer however, is obvious to any thinking student. Tubby and Sir Isaac had flatly refused to allow themselves to be carried; and since gravity on the surface of Jupiter is more than 2½ times that of the Earth, they could hardly stand on their feet, much less walk!

The Great Mogul was a towering giant some fifteen feet tall, with his Counsellors in proportion. A robe of richly-colored cloth fell in folds to his feet. There were ropes of enormous gems about his neck—that is to say they might have been considered gems, though they looked more like little gargoyles moulded out of red and green putty and his braided white beard hung down his chest to his waist.

(*To be continued.*)

NEW CAMERA NEEDS ONLY 10-MILLIONETH OF SECOND

Through an apparatus operated by revolving mirrors, Dr. J. A. Anderson, a member of the staff of Mount Wilson Observatory, can take a photograph with an exposure of one ten-millionth of a second.

Dr. Hackensaw's Secrets

(*Continued from page 504*)

second your wheel must revolve 350 times per second! You surely cannot obtain such a speed as that!"

"Certainly I can. It is just a matter of gearing. Many small wheels in machinery travel more than 350 revolutions per second. But I have a plan that will enable me to run this wheel at a much lower speed. Do you notice the wheel itself revolves over a very deep excavation?"

"Yes, I was wondering what that deep hole was for."

"That is to enable me to increase the diameter of the wheel without increasing it."

"What?" cried Silas, puzzled.

"To be plain, there are serious objections to having the wheel too large, as it would tend to fly apart at the high speed of revolution. On the other hand it must not be too small or the dizzy whirling motion might kill the passengers. So I have devised the following method. I have a very long and very strong chain wound on a windlass anchored to the rock itself. The free end of this chain passes through the axle of my Ferris wheel, up through a hollow spoke and is there attached to the bottom of the car. This chain therefore, encased in a swivelled tubing to avoid twisting, can be gradually let out as the wheel increases in speed. The centrifugal force makes the car move away from the wheel, but it is held by the chain. Gradually as I let the chain out the car describes larger and larger circles. In this manner with a small wheel revolving at a moderate speed, I can obtain the same effect as with a large wheel, and without the attending disadvantages. I use electricty for my motive power and use some ball-bearings, but wherever possible, in order to reduce friction I use a stream of compressed air for the bearings—a little invention of my own."

"I suppose you have to aim your car ahead of the moon," remarked Silas.

SEVEN FACTORS TO CONJURE WITH

"The problem is by no means so simple as that," retorted the doctor. "As a matter of fact, I don't aim anywhere near the moon. Seven factors have to be taken into consideration in aiming the car. First there is the rotation of the earth. The earth revolves on its axis every day. A body at the equator if shot off from the earth would have this centrifugal speed of 1,000 miles per hour in a straight line tangent to the earth. But I see you don't understand. Here is a diagram that will help you. When a body, which is revolving in a circle, is suddenly allowed to fly off, it flies off at a tangent. Thus in the diagram, a body released at either, A, B, C or D will fly off in the direction of the arrow. For the same reason, the direction my car will take will depend largely on the time of the day at which it is released. If released at noon this speed of one thousand miles per hour will be in exactly the opposite direction to what it would be if the car were released at midnight.

"The second factor is similar and depends upon the speed of the earth in its revolution around the sun Here too, the car will fly off at a tangent to the orbit, at a speed of nine miles per second, the direction depending on the day of the year and the time of the day. The third factor of course depends on my revolving wheel. From this, too, the car will fly off at a tangent, its direction depending upon its position on the wheel when released."

"But doctor," asked Silas puzzled, "How can a body travel in three different directions at once?"

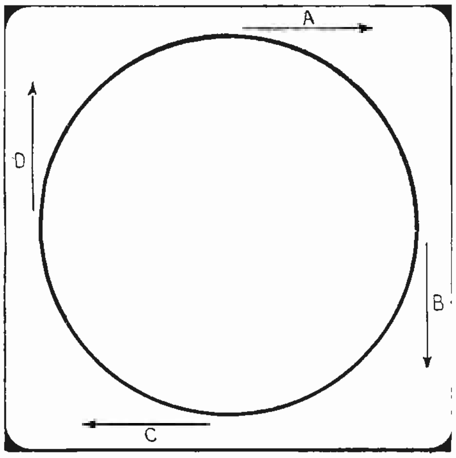

Diagram Showing How a Revolving Body Released at A, B, C, or D Will Fly Off at a Tangent

"These three tangents are all straight lines. When a body is acted upon by three such forces it takes a diagonal course—the average of the three. This is what is known as the law of the composition of forces.

"The next three factors are the attraction exerted on the car by the earth, by the moon, and by the sun. These attractions change as the car moves, hence these forces would each move the car along a curved line. When all six forces are combined the path of the car will also be a curve. The seventh and last important factor to consider is the resistance of the air. The car's flight will be greatly retarded when passing through our atmosphere. Hence this, too, must be allowed for in aiming the car.

"How long will it take your car to reach the moon?"

"The distance is about 240,000 miles. At seven miles per second the speed would be about 25,000 miles per hour. In other words we should reach the moon in less than 10 hours if this speed were maintained. As however the speed continually decreases, owing to the earth's pull backwards, until the car has reached the neutral spot between the earth and the moon and there slowly increases again owing to the increasing attraction of the moon, the calculation of the time required for the trip is rather complicated. I allow for four days, which ought to be more than sufficient. I am running no chances, however, but am taking enough provisions and liquid air to last me for a month."

THE MOON CAR

"Doctor," said Silas, "I notice that your car has accommodation for two passengers. May I ask whom you are sending?"

"I am sending no one."

"You, yourself, are going, then? But how will you get back from the moon?"

"I don't know. The probabilities are that I shall never get back. But I have a wireless apparatus on board capable of sending radio messages from the moon. I have over a month's supply of air, water and provisions. Even if I pay for the trip with my life, I hope to be able to send home descriptions of inventions I see there, and that will far out-balance any scientific research work I could accomplish on the earth."

"When do you start?"

"I start on Thursday of next week."

"Doctor," cried Silas excitedly. "I am going with you!"

"I thought as much," replied Doctor Hackensaw, shaking the reporter warmly by the hand.

And thus these two men, as much for the interests of science as for the love of adventure, cooly resolved to risk their lives in one of the most novel and exciting enterprises ever undertaken by man.

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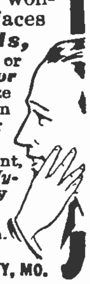

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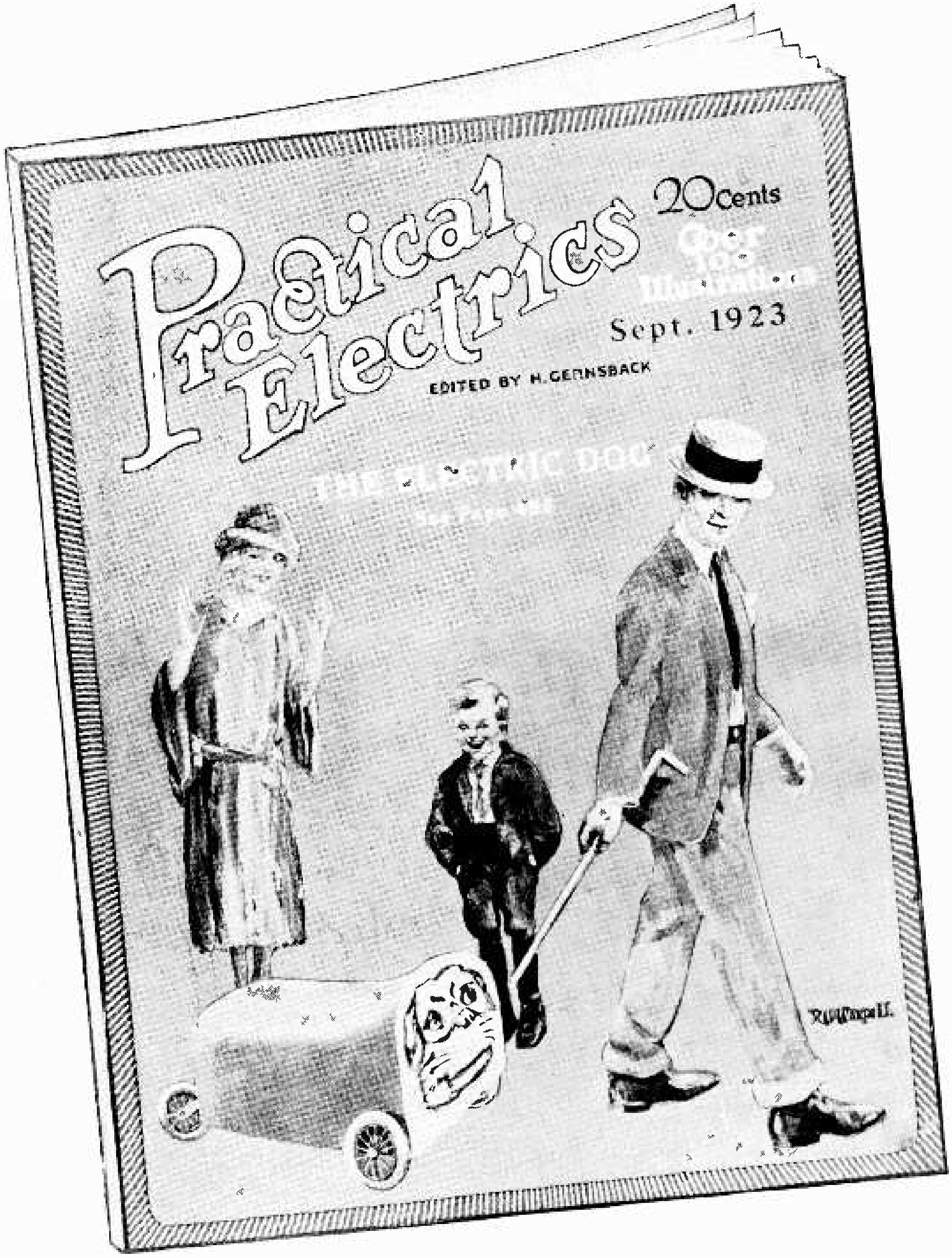

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