SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXXI
NUMBER 2092

★ NEW YORK, FEBRUARY 5, 1916 ★

10 CENTS A COPY
$5.00 A YEAR

A locomotive with a push plow clearing the track near Hobart Mills, California.

THE REGION OF THE GREATEST SNOWFALL.—[See page 88.]

The Structure of the Atom—I*

A Comprehensive Survey of the Development of Theories and the Present Situation

By Dr. K. Fajans

CHEMICAL ELEMENTS AND THEIR ATOMS.

ALL compound substances, on chemical decomposition, may be reduced to a limited number of substances (about 100), which are not capable of being further resolved into other components by any *known* means. These are the chemical elements. A certain quantity of an element, for example copper or oxygen, may be divided into parts which share all of the properties of the original substance, and into no other parts. But according to the atomic theory even this mechanical subdivision has a limit, which is reached for the hydrogen atom (for example) when one gramme has been divided into $6{,}1.10^{23}$ exactly similar particles, which are called hydrogen atoms. Corresponding to the chemical elements, about a hundred kinds of such chemical atoms are thought to exist, and to form the materials from which all other matter is built up.

Very early in the development of the atomic theory the question arose as to whether these atoms of about 100 sorts were really the ultimate indivisible particle, which had no relation with each other, or whether they all sprang from a common parent substance into which they would be sooner or later divided. The effort to form the simplest possible image of their construction strongly favors the latter hypothesis, in spite of the evidence against it, and in 1815 Prout thought that the lightest known substance, the hydrogen atom, was the substance into which all of the elements could be decomposed.

THE PROUT HYPOTHESIS.

Prout cited in support of his hypothesis the quantitative relations between the atomic weights[1] of the elements. According to him the atomic weights of all the elements were whole multiples of the atomic weight of hydrogen, and are to be expressed as whole numbers if the atomic weight of hydrogen H is taken as 1. Each heavier atom may be considered as built up from a definite number of hydrogen atoms.

Knowledge of the exact values of atomic weights was very meager in Prout's time, and the widespread interest attached to his hypothesis stimulated a great many series of atomic weight researches; the results of which were not in harmony with his theory. There was no doubt that while the atomic weights of very many of the elements were, in fact, close to whole multiples of that of hydrogen, the deviations in other cases were far greater than the experimental errors in determining them. The same result was obtained if half or a fourth of the weight of this lightest atom were taken as a standard, and failure in establishing the desired relationship convinced chemists that no simple numerical relation existed among atomic weights.

THE PERIODIC SYSTEM OF THE ELEMENTS.

The development of the periodic system by Mendelejeff and Lothar Meyer (1869) has shown conclusively that the chemical elements are not without relationship. The periodic system (see Table 1) shows the following things: If all the known elements are arranged in the order of increasing atomic weight, the chemical and physical properties recur periodically at certain distances. The elements resembling one another are found under each other in the eight groups which form the system[2] (each group with two sub-groups *a* and *b*). These regularities lead to the conclusion that the atomic weights are the fundamental properties of the elements which determine their other properties.

In the development of the periodic system the old idea of a relationship between the atoms of the elements has received new support, and has served as the starting point for numerous speculations as to the nature of this relation. Only in the latter years of the last century was the next step in advance made, with the discovery of the nature of electricity.

THE ATOMIC NATURE OF ELECTRICITY.

As early as 1881 Helmholtz reached the conclusion that if matter was atomic in structure, electricity must be also. He deduced this from the Faraday law of electrolysis, which claims that, in the sense of the ionic theory,[3] one gramme atom,[4] and therefore one atom, of each monovalent metal (and hydrogen as well) carries the same quantity of electric charge, while an atom of a polyvalent metal carries a whole multiple of this charge. The charge combined with a single atom of a monovalent element is therefore the smallest quantity of electricity occurring in solution, and it was a short step to assume that this was the limit of divisibility—the atom—of electricity. The absolute value of this charge is obtained by dividing the quantity of electricity combined with a gramme atom of a monovalent ion (96,540 coulombs [5]) by the number of atoms in a gramme atom, $6.1.10^{23}$. It is equal to $1.58.10^{-19}$ coulomb, or $1{,}58.10^{-20}$ E. M. E. This charge of electricity is called the *elementary quantum of electricity*, and will be designated by *e* in the following:

The conception of Helmholtz has received abundant confirmation in the last few years. Several methods have been developed by which the very small electric charge on the individual particles can be determined, but in none of them has a charge been discovered which has been conclusively proven to be smaller than *e*, whether positive or negative, nor has a charge been found which is not a whole multiple of *e* in any of these methods. As one of the most interesting researches of this kind, the experiments with alpha-rays of radioactive substances may be mentioned, since they have been of great significance in determining other questions of atomic structure.

TABLE 1.

	VIII	I a b	II a b	III a b	IV a b	V a b	VI a b	VII a b
1 H 1.008	2 He 4,00	3 Li 6,94	4 Be 9,1	5 B 11,0	6 C 12,00	7 N 14,01	8 O 16,00	9 F 19,0
	10 Ne 20,2	11 Na 23,00	12 Mg 24,32	13 Al 27,1	14 Si 28,3	15 P 31,04	16 S 32,07	17 Cl 35,46
	18 A 39,88	19 K 39,10	20 Ca 40,07	21 Se 44,1	22 Ti 48,1	23 V 51,0	24 Cr 52,0	25 Mn 54,93
	26 Fe 55,84 27 Co 58,97 28 Ni 58,68	29 Cu 63,57	30 Zn 65,37	31 Ga 69,9	32 Ge 72,5	33 As 74,96	34 Se 79,2	35 Br 79,92
	36 Kr 82,92	37 Rb 85,45	38 Sr 87,63	39 Y 89,0	40 Zr 90,6	41 Nb 93,5	42 Mo 96,0	43 —
	44 Ru 101,7 45 Rh 102,9 46 Pd 106,7	47 Ag 107,88	48 Cd 112,40	49 In 114,8	50 Sn 119,0	51 Sb 120,02	52 Te 127,5	53 J 126,92
	54 X 130,2	55 Cs 132,81	56 Ba 137,37	57 La 139,0	58 Ce 140,25 59 Pr 140,6	60 Nd 144,3	61— 62 Sm 150,4	63 Eu 152,0
	64 Gd 157,3 65 Tb 159,2 66 Ds 162,5	67 Ho 163,5 68 Er 167,7	69 Tu 168,5	70 Yb 172,0	71 Lu 174,0 72—	73 Ta 181,5	74 W 184,0	75 —
	76 Os 190,9 77 Ir 193,1 78 Pt 195,2	79 Au 197,2	80 Hg 200,6	81 Tl 204,0	82 Pb 207,2	83 Bi 208,0	84 Po (210,0)	85 —
	86 Em (222,0)	87 —	88 Ra 226,0	89 Ac (227)	90 Th 232,4	91 Bv (234,0)	92 U 238,2	

(Under the symbol of each element is its atomic weight, and at the side is its atomic number.)

THE α-RAYS.

There are three kinds of rays which are sent out by radioactive substances, which may be designated as α-, β-, and γ-rays. Only the latter is a true radiation in the narrow sense of the word. These γ-rays are very similar to the Röntgen rays of electromagnetic origin, and must be considered as a type of light wave, from which they are to be distinguished only by an exceedingly short wave length.[6]

The α- and β-rays are, on the contrary, very rapidly moving charged particles. A single *α-particle* (velocity about 9,000 to 12,000 miles, 15,000 to 20,000 kilometers per second) carries one *positive* charge and a single β-particle (velocity between 60,000 and approaching 180,000 miles, 100,000 and approaching 300,000 kilometers per second) one unit of negative charge.

When α-rays fall on zinc sulphide or diamond, they cause the substance to glow. When a very weak radiation is allowed to fall on such a screen, periodic and separated flashes of light (scintillations) may be observed with a microscope. Regener, Rutherford, and Geiger (1908) have experimentally determined, first the number (n) of such light flashes from a given radioactive preparation in a unit time; second, the total positive charge (E) of all the α-rays radiated by the same preparation in the same time. $\frac{E}{n}$ is then the charge corresponding to a single light flash (one α-particle), and this was found to be $2e$. *A single α-particle carries, therefore, a charge double that on a hydrogen ion, i. e., the same charge as an atom of a bivalent metal in solution.*

As has been mentioned before, the gramme-atom of each monovalent element in solution carries this same charge $E = 9{,}654$ E. M. E. The ratio of this charge to the mass (M) which is combined with it has for each ion a certain characteristic value, which is smaller the larger the atomic weight of the element. The largest value of $\frac{E}{M}$ is that for the hydrogen ion, namely, 9,577, since $M = 1.008$. For such charged particles as the α-rays, which are sent out from a radioactive substance with high velocity, and which therefore resemble an electric current, the value of $\frac{E}{M}$ and the velocity of the particle can be simultaneously determined from the deviations from a straight line path which are caused by electric and magnetic fields. In this way Rutherford (1903 and 1913) found for α-particles the value $\frac{E}{M} = 4{,}821$ E. M. E., or roughly half that of the hydrogen atom. It was found, however, that for an α-particle $E = 2e$, or twice the charge of a hydrogen ion. It follows, then, that an α-particle must be about four times as heavy as a hydrogen atom, namely, 4.00. But this number agrees exactly with the atomic weight of helium, and Rutherford was in this way brought to the conclusion that an *α-particle is a positively charged helium atom,* and this was spectroscopically proven (1909).

THE NEGATIVE ELECTRON.

The same method of electric and magnetic deviations

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Die Umschau.*

[1] The atom of each element has a definite weight, whose relative magnitude, referred to oxygen 16 as an arbitrary standard, is called the "atomic weight" of the element. These atomic weights may be determined with great exactness from the weight relations in which the elements enter into chemical combination with oxygen. They are given in Table 1 under the symbol for each element.

[2] Several elements give cause for difficulty in the arrangement of this system, but this cannot be taken up in this place.

[3] According to the ionic theory of solutions, acids, bases and salts in aqueous solution are dissociated into charged particles—ions; e. g., hydrochloric acid (HCl) into the positively charged hydrogen ion H^+ and the negatively charged chloride ion Cl^-.

[4] A gramme atom is that number of grammes of an element which is equal to its atomic weight, i. e., 1.008 for hydrogen, 16 for oxygen. A gramme atom of each element contains, therefore, the same number of atoms, namely, $6{,}1.10^{23}$, as can be shown from several phenomena.

[5] A coulomb is that quantity of electricity which flows through the cross section of a conductor when a current of one ampere flows for one second. Ten coulombs is the so-called electromagnetic unit of electricity, E. M. E.

[6] While the wave length of the red light rays is about 7.10^{-5} centimeter, that of the violet 4.10^{-5}, the γ-rays have wave lengths of between 10^{-8} and 10^{-9} centimeter.

has been applied by Lenard and J. J. Thomson (1897) to the study of cathode rays, which are expelled from the negative electrode (cathode) with high velocity during electric discharge in gases at very low pressures, and which give rise to Röntgen rays when they strike the walls of the containing vessel opposite the cathode or some other solid object in front of the electrode (anticathode). These rays carry *negative electricity*, and the determination of the ratio $\frac{E}{M}$ for them gives the value (for very slow rays) 1,77.10[7] E. M. E., *a value* 1850 *times as great as that for the hydrogen ion.*

There are two possible assumptions on which to explain this exceedingly high value of $\frac{E}{M}$; if the mass of the cathode-ray is of the same order of magnitude as that of the hydrogen atom, then its negative charge must be very much greater than *e*. Or, if the *charge is equal to e, then the mass must be* 1850 *times smaller than that of the hydrogen atom*—the lightest of the known atoms.

Much evidence points to the second alternative as the correct one, and there is considerable interest attached to the question of the nature of this particle with such a small mass. Is it perhaps a new element with such a small value of its atomic weight as appears from the cathode ray particles? In the consideration of this question it must be remembered that according to the electromagnetic theory a moving electrically charged particle behaves as if its mass were greater than the mass of the same particle in the uncharged condition. This increase in mass for a sphere of radius a and charge e is equal to[7] $\frac{2e^2}{3a}$. The mass arising from the electric charge is called electro-magnetic mass. It has not been possible to determine with certainty what part of the total mass of a cathode ray particle is due to this electromagnetic increase, for in the expression $m = \frac{2e^2}{3a}$ the radius a is not known. The assumption is usually made that the *total mass of the cathode ray particle is of electromagnetic origin*, and that therefore nothing would remain of it if the electric charge were removed; the particle becomes, then, the free atom of negative electricity. This particle is called the negative electron. Its radius may be computed from the equation $a = \frac{2}{3}\ (e/m)e = \frac{2}{3} \cdot 1{,}77.10^{-7}\ 1{,}58.10^{-20} = 1{,}9.10^{-13}$ centimeter. But the radius of an atom is of the order of 10^{-8} centimeter, so that the electron is considerably smaller than an atom, which is in agreement with its properties.

The discovery of particles with such small masses and dimensions led to the development of the problem of the structure of the atom in a wholly new way: the question arose whether the electron, i. e., electricity, might not be the original material from which all of the atoms were built up. In fact, it has been possible to show that negative electrons are contained in the atoms of all elements, and can be separated from them without difficulty. Cathode rays are obtained in a discharge tube without regard for the nature of the metal of which the electrodes are composed, or the nature of the gas (at low pressure) which fills the discharge tube. It is also possible to obtain electrons from certain substances by heating them to high temperatures and bombarding them with Röntgen rays or radium rays. It has been further shown that electrons are liberated during the progress of many chemical reactions. *Finally, the β-rays of radioactive substances are nothing else than rapidly moving electrons.* It can also be shown that the light emitted from a substance at a high temperature is conditioned by the motion of the electrons within the atom.

POSITIVE ELECTRICITY.

When a neutral atom loses electrons it retains for itself a positive charge, i. e., it becomes a positive ion. For example, an *a*-particle can be considered as a helium atom which has lost two electrons.

Though it has been shown that the negative electron is a constituent part of the chemical atoms, the question of their structure is still unsettled, so long as we do not know what characterizes positive ions, or in other words, so long as we do not know the nature of positive electricity. The simplest assumption which can be made is naturally that there are positive as well as negative electrons, which differ from each other only in the sign of the charge, and that the neutral atom is made of an equal number of these positive and negative electrons. There are, however, great difficulties in connection with this theory, for in spite of many attempts, *it has not been possible to obtain positively charged particles whose mass is less than that of the hydrogen atom.* Further, if the positive electron is as small as the negative electron, the mass of the atom can be made up of only these electrons, and it would require 925 of each kind for a hydrogen atom, and for the heavier atoms correspondingly more, for the mass of the negative electron is 1,850 times smaller than that of the hydrogen atom.

Now there are several phenomena which give us an approximate knowledge of the number of electrons in the atom. Cathode rays and Röntgen rays as well as *a*-, *β*-, and *γ*-rays possess the power of penetrating atoms, and during this they experience deflections from their straight line paths, which not only shows conclusively that electric charges are present in the interior of atoms, but (with the help of certain assumptions as to the distribution of these charges within the atom) enable us to calculate their magnitude. Indeed, it can be shown by this method that the number of electrons in an atom is roughly proportional to its atomic weight, and that the number in the hydrogen atom is not about 1,000, but of the order of one. It follows from this fact, therefore, that only a small part of the atomic mass is to be attributed to the electron, and that the *larger part of the mass of the atom is inseparably united to the positive electricity which is found within it.* If it is assumed that the atom consists only of positive and negative electricity, and there is much ground for such an assumption, then this is only possible if the mass of the positive electron with the charge equal to *e* has about 1,000 times the mass ascribed to the negative electron. If the mass of the positive electron is also of purely electromagnetic origin, it follows from the expression $a = \frac{2e^2}{3m}$ that the radius of the positive electron must be 1,000 times smaller than that of the negative electron, namely, of the order of 10^{-16} centimeter (Nicholson, 1911).

We will now consider in closer detail in what manner the atom is thought to be built up of positive and negative electricity. There is another point of view, based on the Prout hypothesis, from which one can consider the structure of the atom. According to Prout, the hydrogen atom was the material from which all other substances were constructed. Now it is known with certainty that another substance, namely, *helium, forms a constituent part of many of the elements.* As was first shown by Ramsay and Soddy (1903), helium is steadily produced by radium preparations, and as may be seen from what has been said, this is directly connected with the emission of *a*-particles by radioactive substances. An explanation for these phenomena is to be found in the theory of radioactive transformations of Rutherford and Soddy (1902).

RADIOACTIVE TRANSFORMATIONS.

According to this theory, the correctness of which has been definitely established, the nature of the processes taking place in radium and other radioactive substances, consists in a *transformation of the elements.* An atom of radium, for example, is decomposed into an atom of helium (which is ejected from the atom in the charged condition as an *a*-particle) and an atom of a new element, the so-called "radium emanation," which is itself still further decomposed. *The radioactive elements are therefore unstable*, and in fact each one of them has a definite velocity of transformation which is absolutely independent of all physical and chemical influences. This is usually expressed as the half-time value, i. e., that time in which half of a certain quantity of the element which is present is decomposed. The half time value for radium emanation is only 3.85 days, that for radium is 1750 years. Only about thirty-five radioactive elements are known, of which the most are so short lived that they are not to be had in weighable quantities. Their identification offers no special difficulties, however, for they are characterized by the properties of their radiations, their velocities of decomposition, and also their chemical properties. These elements form three genetic families, or transformation series, the uranium-radium series, thorium series, and actinium series. Only the first series is shown here, with the omission of some secondary products which are not necessary for our purpose. (Table 2.)

TABLE 2.

1 Name of Element.	2 Radiation.	3 Atomic Weights.	4 Chemical Properties.	5 Groups.	6 Order of Numbers.	7 Half-time Value.
Uranium 1		238.2	U in Table 1	VIa	92	5 . 10^9 Years
↓	*a*					
Uranium X_1		(234.0)	as Thorium	IVa	90	24.6 Days
↓	*β*					
Uranium X_2		(234.0)	Brevium (Bv) in Table 1.	Va	91	1.15 Minutes
↓	*β*					
Uranium 2		(234.0)	as Uranium	VIa	92	10^6 Years
↓	*a*					
Ionium		(230.0)	as Thorium	IVa	90	10^5 "
↓	*a*					
Radium		226.0	Ra in Table 1	IIa	88	1750 "
↓	*a*					
Ra-Emanation		(222.0)	Em in Table 1	O(VIII)	86	3.85 Days
↓	*a*					
Radium A		(218.0)	as Polonium	VIb	84	3.0 Minutes
↓	*a*					
Radium B		(214.0)	as Lead	IVb	82	26.7 "
↓	*β*					
Radium C_1		(214.0)	as Bismuth	Vb	83	19.5 "
↓	*β*					
Radium C′		(214.0)	(as Polonium)	(VIb)	(84)	(10^{-6} Second)
↓	*a*					
Radium D		(210.0)	as Lead	IVb	82	16 Years
↓	*β*					
Radium E		(210.0)	as Bismuth	Vb	83	5 Days
↓	*β*					
Radium F		(210.0)	Polonium (Po) in Table 1	VIb	84	136 Days
↓	*a*					
Radium G		(206.0)	as Lead	IVb	82	

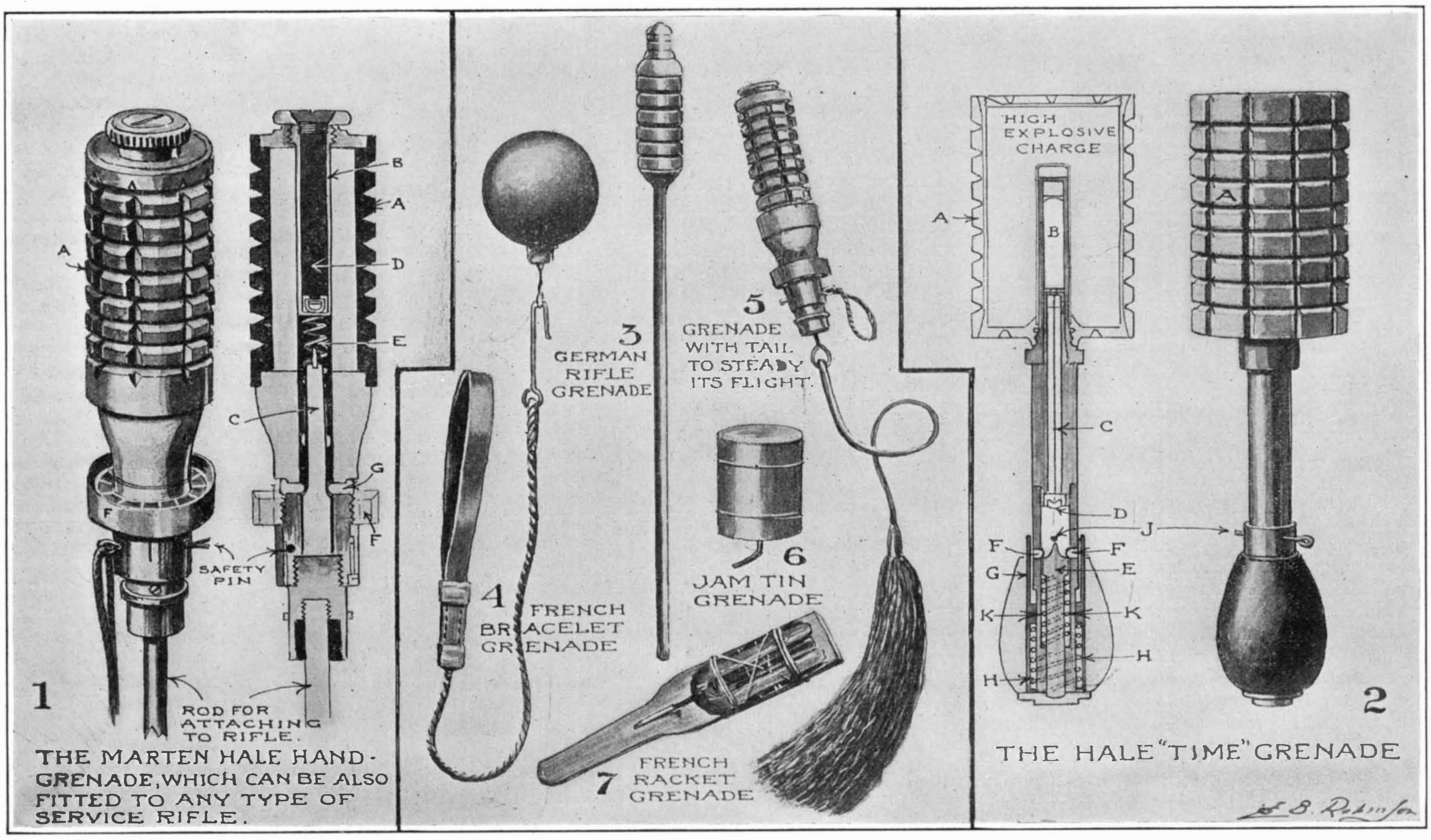
The arrow indicates that the preceding element of the table is transformed into the following, with the emission of the type of radiation given between the elements (in the second column), which, as may be seen, is either *a*- or *β*-particles in each case. The *γ*-rays, which are mostly associated with the *β*-rays, but in some cases with the *a*-rays also, are not shown here, since they are not necessary for this discussion.

(To be continued.)

[7] The explanation of the increase in mass of a moving charged particle is that its motion is the cause of an electric current which gives rise to a magnetic field in the surrounding medium, for which energy is required. For a particle of spherical shape, of radius *a*, and charge *e*, moving with a velocity *v*, the increase in mass is equal to $\frac{1e^2}{3a} v^2$ and this is added to the kinetic energy of the particle $\frac{1}{2} Mv^2$. Its total energy is therefore equal to $\frac{1}{2} (M + \frac{2}{3} e^2/a) v^2$. This charge has therefore the effect of increasing the mass by $m = \frac{2e^2}{3a}$.

Copper Cartridge Cases

WRITING on the subject of the manufacture of cartridge metal, in which zinc of 99.9 per cent purity is used, a correspondent, "Metallicus," states that, after fifteen years' practical experience of metal manufacturing and hot and cold rolling, he does not see why the present very expensive cartridge and shell-case metal should not be displaced by hot rolled, tough copper, accurately finished by the ordinary cold rolling process. The finished cartridge and shell-case can be drawn just as easily from copper as from the present expensive metal, and can be made much more rapidly and by more manufacturers, as there are a large number of hot-rolling mills at present manufacturing copper sheet and strip whose extensive plant could be utilized, and in addition a very large saving would be effected as well as there being made available an almost unlimited supply of metal.—*The London Daily Telegraph.*



Courtesy of the *Illustrated War News*

Grenades—rifle and hand—in everyday use at the front.

When the bomb is thrown, the ignition of the time-fuse does not occur until the grenade reaches a distance equal to the full length of the line, the extension causing the line to pull out the friction-tube. If the man be killed in the act of throwing, the grenade falls harmlessly beside him, as the line is sufficiently long to permit of its reaching the ground without pulling out the ignition device. Improvised grenades are made in several different ways, according to the materials to hand. A jam or beef-tin, for one, filled with an explosive, and fitted with a length of fuse, is a device which is quickly made and is capable of doing effective work at short ranges. The fuse in this case has to be lighted before the missile is thrown.—(Drawings by W. B. Robinson.)

Grenades, Rifle and Hand*

Missiles Used in Close Range Fighting

The hand-to-hand fighting which is of everyday occurrence in the present war has favored the use of the grenade in its various forms. All consist of a small shell, or canister, containing an explosive charge which is designed to burst when it reaches the object to be destroyed.

Grenades are made to be thrown either from a rifle, a catapult, or by hand. They are exploded at the desired moment by a percussion-cap ignited when the grenade strikes an obstacle, or by a time-fuse which is lighted when or before the missile leaves the thrower. In the first case, the percussion-cap fires the detonator which explodes the bursting charge; in the second, a similar detonator is used, but it is fired after a lapse of about five seconds, the time occupied by the burning of the fuse. This length of time may be varied by altering the length of fuse employed.

In some cases the grenade is so designed that it can be adapted for use either by hand or from a rifle. The Marten-Hale is of this type (Fig. 1). It consists of a grooved steel cylinder (*A*) having a tube (*B*) through its axial center, the tube being provided at its after end with "floating" striker (*C*). At its forward end is a percussion-capped detonator (*D*). The two are kept apart by a coil-spring (*E*). The steel cylinder (*A*) is reduced in diameter at its after end, and a collar (*F*) is screwed on the reduced portion. The collar is fitted with sloping wind-vanes which cause it to revolve as the missile passes through the air, and in so doing to screw itself so far back as to allow radial safety-pins (*G*) to recede and free the firing-pin. That, on the grenade striking an obstacle, is carried forward by its own momentum, overcoming the pressure of the separating spring (*E*), until it strikes and explodes the percussion-cap attached to the detonator. So the explosion of the bursting charge of high explosive filling the shell of the cylinder round the central tube is caused.

The Hale "time" grenade (Fig. 2) has the usual grooved cylinder (*A*) carrying a detonator (*B*) in its center, with a time-fuse (*C*) extending down the center of the hollow tail, or handle, the time-fuse being fitted with a percussion-cap (*D*) at its outer end. The extremity of the tail contains a spring operated by a striking-pin (*E*), which is retained in a "cocked" position by radial pins (*F*) at its nose similar to those employed for the same purpose in the percussion grenade (seen in Fig. 1). These pins are held in by an outside sleeve (*G*) to which the handle is attached, the sleeve being pressed up to its work by an exterior coil-spring (*H*). A removable safety-pin (*J*) passes through the sleeve and tail-piece when the grenade is not in use, and is only removed by the thrower at the last moment.

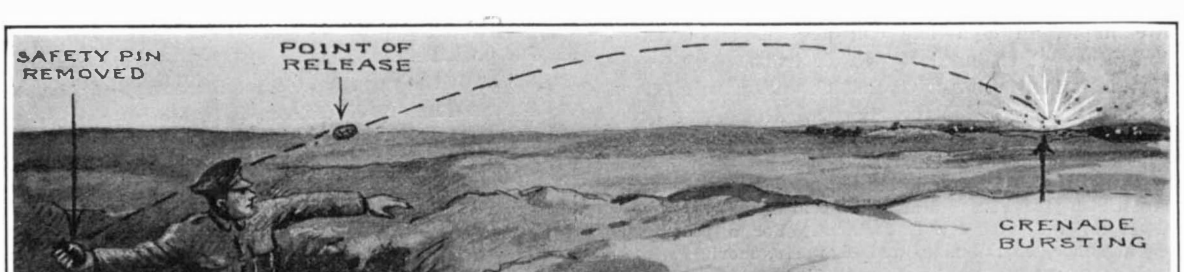
The action is as follows: The safety-pin (*J*) having been removed, the thrower grips the grenade by the handle at its extreme end and swings it forward in throwing it. The centrifugal force set up by the shell itself (*A*) during this swing pulls it forward against the exterior coil-spring (*H*), so that the radial safety-pins (*F*) are uncovered by the sleeve (*G*). The striking-pin (*E*) is enabled to push them out of its way as the interior spring (*K*) drives it forward to strike the percussion-cap (*D*) on the end of the time-fuse (*C*) and cause the explosion of the grenade as soon as the fire passing along the time-fuse reaches the detonator (*B*). When thrown by hand, the Hale grenade has a rope tail attached to it to ensure it striking nose first. When fired from a rifle, a stick like that of a rocket answers the same purpose, and fits the barrel.

A time-grenade whose fuse is ignited by the thrower before he throws it becomes a source of danger to his comrades if the man be unfortunate enough to be shot while in the act of throwing. In that case he is likely to drop the missile with its ignited fuse in the trench among them. The bracelet-grenade (Fig. 4), used by the French, is designed to overcome this difficulty. The thrower of this is provided with a leather bracelet to be strapped round his waist, with, permanently attached, a length of cord bearing a hook at its free end. This grenade has a time-fuse which is ignited by the action of a friction-tube whose outer end carries a ring or for attachment to the hook on the thrower's wrist-line.

* *The Illustrated War News.*

A 5,000-Horse-Power Chain Drive

In a description in *Power* of an electric power plant in the Northwest interesting details are given of an application of the chain drive on a large scale. Owing to unavoidable conditions it was not possible to obtain the expected speed from the water wheels, so it was necessary to gear up the electric generators. This was done by introducing a chain drive between the wheels and the generators. Each of the two water-wheel shafts carries a 71-tooth sprocket wheel of 45.49 inches in diameter. The generator shaft carries two 47-tooth sprockets 30.31 inches in diameter. The four Morse silent driving chains on each pair of sprockets are 31.67 feet long by 21 inches wide, weighing about 2,800 pounds each. The pitch is 2 inches. The sprockets, in halves, are bolted to the shafts, which are 129 inches center to center. The speeds of water wheels and generator are 149 and 225 revolutions per minute. The chains have been tested to 40,000 pounds per square inch; under ordinary working conditions the stress is 600 pounds per square inch.



Throwing a grenade by hand: From fling to burst.

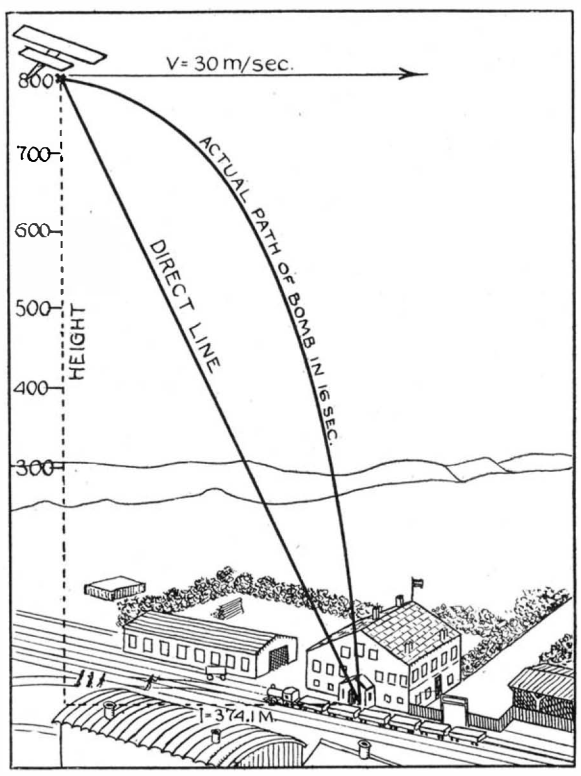
This diagrammatic sketch shows the method of flinging hand-grenades. The average length of throw varies, according to the strength of the thrower and weight of the bomb, ordinarily between 25 and 40 or 50 yards. From the moment of release to the moment of burst is 5 seconds, the time for which the fuse is set to burn.

Throwing Bombs from Airships*

How to Aim the Projectile to Hit a Given Object

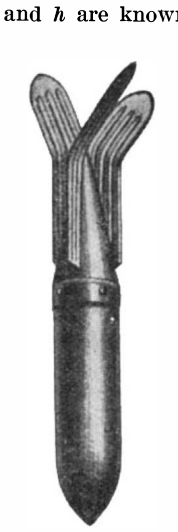
By Alexander Buttner

The unprecedented progress made in the art of flying in the past few years, the many improvements, new types of construction, alterations in models made in airships, have been of such importance that a wholly new and unexpected value has become attached to them in the present war. We no longer use flying machines and airships merely to observe and reconnoiter, but also for making attacks from the air, in a manner wholly unimaginable before. The idea of throwing explosives from the air into the enemy has ruled in fancy for over a hundred years. In newspapers of the year 1784 (one year after the discovery of the first hot-air balloon by Montgolfier) small notices and paragraphs on this topic appeared. But the actual accomplishment of the idea was reserved for the following century, when the Austrians in the war of 1849 dropped bombs from (unguided) balloons on the Venetians.[1] The experiments were, however, of little consequence, and were soon abandoned, since an explosive thrown from an uncontrolled balloon has small chance of being effective. Since that time much has been done toward the solution of the new problem of a controlled airship, especially in England and France, largely the result of the zeal of private persons. One may estimate the fruitfulness of this endeavor by the immediate appearance of great improvements; so that bombs thrown from aircraft have become a dreadful weapon in the time of war. In the Hague Peace Conference of 1899 a law was passed forbidding the use of air-going craft for dropping explosives during the next five years, but in 1911 the law was taken up again by most large countries, such as Germany and France, and judged to have become useless as a law; and the practice was considered no longer forbidden. After the discovery (in 1904) of the semi-motionless airship of Lebaudy in France, the bomb-throwing experiments were again taken up in Toul, using a controllable aircraft. In spite of the poor results obtained, the experiments have been repeated by most countries. In the last three or four years, before the outbreak of the war, many flying planes of different sizes were manufactured in Germany (at the spring flying meet in Johannis Valley in 1912) and in foreign countries (in France high prizes were offered by Michelin), and competitive shooting was carried on in which 45 per cent of strikes was attained. It was only by the use of great skill and much practice that the bomb could be made to hit the target with certainty. About two years ago an American (Scott) constructed an aiming device which, in spite of its amazing simplicity, gave satisfactory results, and was copied within a few months practically unchanged by France and England. It has received little attention in Germany. This apparatus determines without difficulty, from the velocity of fall of the shot and the velocity and height of the aeroplane, the moment when the shot must be discharged to hit a certain target. According to the law governing the velocity of fall of an object, this velocity is proportional to the square of the time of falling. A bomb falls toward the earth, therefore, with a steadily increasing velocity, so that in 1, 2, 3, 4, . . . t seconds about $1^2 . 5 = 5$, $2^2 . 5 = 20$, $3^2 . 5 = 45$, $4^2 . 5 = 80$, . . . $t^2 .5 = x$ meters are traversed in falling. If the bomb is thrown from an airship which has itself a velocity of 30 meters per second, it has also this velocity. So the projectile, in place of falling in a perpendicular line from the position of the airship (provided this does not change the direction of its flight), it falls in a parabola. Assume, for example, that the airship is flying 800 meters above the target which is to be struck; the bomb must be thrown at a point P (see Fig. 1) such that $(t = \sqrt{160} = 12.47)$ seconds are allowed for its fall, and when the aeroplane has yet $(12.47 \cdot 30) = 374.1$ meters to fly before coming over the target. The action of the firing apparatus must take place at the instant when the angle between the perpendicular and the target is a. This angle naturally increases with the velocity of flight for equal



Path of flight of an air bomb thrown from an aeroplane.

heights of flying, and is equal to zero when the flying machine is stationary and directly perpendicular to the target. (It follows that the accuracy of fire from a controlled balloon [Zeppelin or Schütte-Lanz] is much greater than from a rapidly moving aeroplane.) The angle a depends on l and h, and is $\frac{l}{h} = \tan. a$; l changes when the velocity of flight increases or decreases. Hence the angle a can be calculated when l and h are known. In order to reduce to a minimum



An English air bomb.

French air bomb used in the raid on Karlsruhe.

the time consumed in this calculation, a telescope is mounted on a vertical arc scale, and the angle read directly on the scale. After the height and velocity of flight have been established, it is only necessary to set the telescope at a certain angle on the scale, and when the target comes into view, through the telescope, discharge the bomb. The position on the scale can be determined directly from the height of flight and the velocity. The altitude of flight may be easily determined from barometer readings or other altitude readings; but the determination of the true velocity is a matter of greater difficulty and uncertainty, since it is calculated from the number of revolutions of the propeller per minute. Side and head winds, irregularities in the motor action itself, small irregularities in flying on account of weather or wind variations, etc., all tend to make more difficult the determination of the true speed of the aeroplane. However, an experienced air-man is able with the help of this or a similar apparatus, to hit targets with considerable accuracy from great altitudes. In the newest forms of bomb apparatus the discharge of the explosive is wholly automatic, through the release of a trigger with the foot. When the trigger is allowed to come into its original position, a new bomb automatically comes into the apparatus. It may be said that through these discoveries and their wide application during the war considerable may be accomplished.

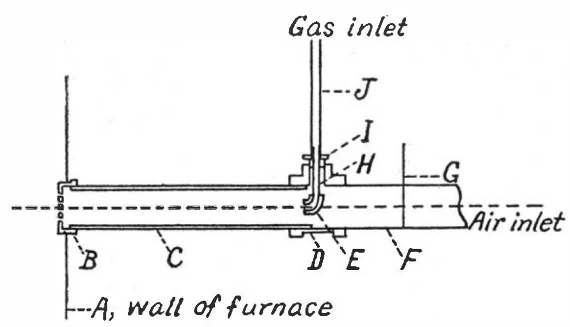
* From *Die Umschau.*

[1] In 1849 Count Thurn-Valsassina was in command of the forces beseiging the Venetians, and with the help of Montgolfier he attempted to drop bombs designed by an artillery officer, Uchatius, into the city. As to the nature of these bombs, we find the following bulletin: "Venice, June 24, 1849. Yesterday we tried out the bomb-dropping Montgolfiers, and sent them to Campalto. The wind was from east and southeast, with no wind from the Alps, which was necessary to carry the unguided destroyers over the island. These balloons were of watertight material and carried as ballast a heavy wooden hoop containing a 30-pound bomb. The balloons were made to lose air after a certain time by the discharge of a rocket with a time-fuse mounted in the hoop, and then dropped vertically, as a burning shell." After a long explanation, the notice closes: : "Finally there was a north breeze, and the two ingenious physicists (Augustin and Uchatius) seized the opportunity to send up several more bomb balloons. All went well at first, the balloons rose rapidly, and approached the position of the Venetians. But in the upper strata there was a sea wind; the airships moved erratically back and forth, and finally fell harmlessly into the sea. The Venetians could well call with light hearts, Affidavit Deus et dissipati sunt." (God blows it, and it is destroyed.)

A Simple Gas Burner for Small Laboratory Furnaces

The burner described below was devised to use natural gas instead of gasoline in heating a small assay furnace of the combined muffle and crucible type. Its merit lies in its simplicity and cheapness, as it can easily be made by any pipe fitter.

A section of the burner is given in the accompanying figure and it is constructed as follows: The part *C* is a piece of 2-inch iron pipe about a foot long. On one end of this is screwed a cap *B*, and on the other a tee *D*, 2 × 3¼ inches. In the end of the cap as many ⅛-inch holes as possible are bored. The air is led into the burner through the large end of the tee. This air is supplied by a centrifugal blower and is under a pressure of about ½ inch of water. Into the side opening of the tee is screwed a bushing *I*, ¾ to ¼ inch, and into this is screwed the ¼-inch pipe that admits the gas. The lower end of this pipe *J* is tapped out to receive the ⅛-inch pipe *H* and to the lower end of this is screwed the ⅛-inch elbow *E*. A stopcock, not shown in the figure, regulates the gas supply while the air supply is regulated by the damper *G*.



The burner so constructed, when properly adjusted, burns very steadily at the openings at the end of the burner. There is no danger of it snapping back and a temperature sufficiently high for all assay purposes is easily obtained. This simple burner will doubtless be useful in heating other forms of apparatus and the writer sees no reason why it could not be used with any form of fuel gas.—D. L. Randall, in *The Journal of Industrial and Engineering Chemistry.*

Telephoning from the Body

Prof. D'Arsonval lately presented to the Académie de Médecine an interesting series of researches made by Dr. J. Glover upon a new method of telephoning in which the microphone transmitter is placed against the human body. He had the habit of making an auscultation of patients by using a telephone transmitter placed upon the body, while the observer listens in the receiver, and found that when the person spoke, his voice was heard in the receiver much more distinctly than in the usual way of speaking before the microphone. In fact, the sounds are transmitted better by the body than through the air, and all outside noises are eliminated such as often cause disturbances. Thus it is an easy matter to telephone with face and hands free and with the transmitter applied say on the chest or back. In this case the voice is heard in the receiver with remarkable clearness, and this precision is also shown by the oscillograph curves which he made. Such a method of telephoning might possibly be put to practical use.

Some Notes on Optical Glass*

An Outline of Manufacturing Processes

By S. Lamb, A.R.S.M.

It is not my intention to attempt to cover any more than a very small portion of the ground enclosed under the head of "Optical Glass," not only because the time at my disposal is so short, but minute details in connection with the subject would have no interest to many persons present. My proposal this evening is not to treat it purely from a scientific side, but to give an idea to the members of this Society not only of the method by which optical glass is manufactured, but the essential qualities of the material.

The uninitiated judge glass from one standpoint only, and this is the quality of color freedom; and unless color has been introduced for a particular purpose, the result is in a great measure a reflection of the respective qualities. Ordinary table ware is in many cases very free from color, and even window glass, if viewed in thin sections, does not show it to a pronounced degree. The best of our ordinary glassware, if compared in strips of about 3 feet long with optical glass such as B. S. Crown, falls deficient in respect of color freedom, for this is one of the most important qualities of glass for optical purposes.

There is, however, another very important difference between the commoner articles of glass which may only be observed by a careful comparison. It will be seen that in ordinary glassware there are very fine, silklike threads, which may appear more pronounced in some samples than others, but whose presence would be a very serious item should the glass be used for anything except the cheapest optical purposes.

These fine silklike threads are called striæ, and may be seen readily in the base of the ordinary tumbler; sometimes they may be detected in sheet glass intended for window glazing, even on looking through the two faces. By the methods of production of ordinary glassware these striæ cannot be avoided, but it will be seen when describing optical glass production that special methods must be adopted to eliminate them from the finished product.

Window or glazing glass is one of the commonest because of its abundant use, and is produced from fluid glass by blowing, rolling, casting or pressing. In each case, however, the aim is to obtain sheets of uniform thickness, so that it will only be necessary for me to mention one of these processes to illustrate the method of manufacture.

WINDOW GLASS.

The raw material from which this is made consists of essentially sand, lime, and a suitable form of alkali, with a small amount of other less important ingredients which constitute what is commonly known as Frit. With this is, however, mixed pieces of broken glass which have accumulated during previous work. The furnaces in which such glass is made are of great capacity, holding as much as 400 tons of fluid material, and in general are heated by gas, being much hotter at one end than the other.

The raw material is introduced at one end (the hotter), where it melts, this being essentially the glass-making end. The other end is known as the working end, being somewhat cooler, and from this place workmen are continually taking quantities for their manipulation.

The furnace is thus continuous, and no attempt is made to perfectly mix the fluid glass, so that layers of varying density exist from the top to the bottom of the fluid mass. In order to work the glass the workman gathers the requisite amount on an iron tube known as a pipe, and, with successive warmings, proceeds to "blow" what may be very much likened to a "soap bubble." The product is not, however, a sphere, but a cylinder with rounded ends, being thus formed by a combination of the internal air pressure and gravitational force.

Now it will be obvious that taking for granted that the glass is in layers of different densities, these become wrapped one above the other as concentric spheres, all of which are expanded to lie like superimposed sheets. This will explain why sheet glass does not show a very striated appearance when viewed through its flat faces, but becomes very noticeable on edge viewing. This lack of homogeneity is not at all serious in such glass as sheet, but it is one of the most serious defects in optical glass.

Optical glass, as we know it to-day, is quite a modern product, and the names of many famous men are associated with the developments not only in the production of meltings on a small laboratory scale, but with improvements which have taken place in the art of manufacture. Of the earliest we may note such names as Fraunhofer, Guinand, Harcourt, Stokes, Hopkinson, Boutemp. The work of these, along with numerous other investigators, was not only to improve the methods by which means large pieces of homogeneous glass could be obtained, but to extend the series by means of small scale trials.

Stokes gives, in the British Association Reports, 1871–1874, an account of Harcourt's work, from which we learn that he produced 166 small meltings, but the great difficulty of rendering the glass sufficiently homogeneous to allow accurate spectroscopic determinations, did not appear to be overcome. Prof. Abbé, in 1876, after referring to Stokes' reports on Harcourt's work, laid the foundation stone of the subsequent important developments in optical glass. His remarks induced Dr. Schött to take up the question, and in 1881 a joint investigation was commenced, the ultimate results of which are known to the whole of the optical world.

The underlying principles of optical glass manufacture have not been altered in a marked degree, although the glasses available for use have been increased in number, and certain operations, such as annealing, have been much improved.

MANUFACTURE OF OPTICAL GLASS.

The furnace used is, comparatively speaking, small, containing what is called a pot or crucible in which the glass is made and allowed to cool, being broken up when the melting is completed.

The pot is built by hand from fireclay whose plasticity has been rendered about equal to that of putty by the requisite water additions. It is allowed to dry very slowly for a period extending over at least six months, in order to lose all water except that of combination. In this state it is fairly hard and can be handled, provided undue roughness is avoided.

Assuming that a pot has been passed for use, it is placed in a furnace known as a "pot arch," and its temperature gradually raised in order to remove the combined water and to burn the pot as hard as possible. During this operation the pot is raised to approximately as high a temperature as that of the glass-making furnace into which it is ultimately placed.

At the end of seven days the burning may be considered complete, when the red-hot pot is picked up by a machine and placed in the making furnace, and the aperture through which it is introduced is well bricked up and covered with fireclay. During the transference of the pot it is struck lightly with an iron bar, and when the sound emitted is clear and bell-like, its further treatment is not attended with such anxiety as one whose note is very dull—the latter usually indicating unseen flaws.

After the pot has been placed in the furnace it is allowed to remain for several hours, during which time it attains a bright red heat and the raw material is being prepared. This raw material, of course, depends on the nature of the glass under preparation, but in any case only the purest ingredients can be used in order that the color may be maintained at its highest possible standard.

For flint glasses such materials as lead oxide, alkali and sand are used; and for crowns, sand, lime, oxide of barium, alkali, oxide of zinc, oxide of alumina, boric acid, etc., in amounts depending on the optical constants required.

At the end of the warming period (six hours) the glazing material, which consists of small pieces of glass from previous pots of similar glass, is introduced, and as soon as melted the inside of the pot is covered with the molten glass—an operation technically called "glazing."

After a further interval of about two hours the raw material (to which has been added some small pieces of broken glass) is introduced a little at a time, each "filling" being allowed to melt before another is added. This alternate adding of raw mixture and heating is continued until the pot is filled, when the heat of the furnace is raised in order to free the glass from bubbles. This operation is one of the most important, and the success or failure of any particular pot depends very much on the care taken and the judgment exercised during this period.

For every glass there is an important range at which successful working is possible—too low a temperature does not allow the bubbles to escape while too high a temperature results in the fire-clay of which the pot is made being severely attacked, and defects appear which will be mentioned later. This temperature, which is different for different glasses, is maintained for several hours, during which time small trial pieces are withdrawn frequently to test the progress. When no bubbles are seen on the trials the operation is at an end, and the temperature is allowed to slightly fall during the next four hours, when the mouth of the pot is opened and any "scum" which has been carried to the surface on account of its lightness is taken off.

The glass at this stage should be free from all defects, except that it is by no means homogeneous, and even small pieces would show an abundance of similar defects to those mentioned when speaking of commoner glass, i.e., veins or striæ.

REMOVAL OF STRIÆ.

Stirring.—The aim of this operation is to remove these striæ, and to Guinand is due the credit of first introducing the method by which such is possible. The "stirrer" consists of a rod of fireclay similar in composition to the pot in which the glass is made, being solid for its whole length, except a small recess at one end, in which a curved metal rod can be fitted. This rod is continued over a swivel wheel situated close to the furnace, and ends in a suitable handle, by which means it is guided round and round the pot.

The operation is continued from four to fifteen hours, according to the glass, and is very trying to the men, who have to be changed at frequent intervals. The glass is, however, cooling down gradually, and when it becomes so viscous that the stirrer can only be moved with difficulty, it is removed, and the pot with its contents is picked up and transferred to an annealing oven, where it is allowed to cool.

During cooling the mass breaks up into innumerable pieces, varying in size from the very smallest up to several hundredweights, which are carefully sorted over and defective pieces rejected, the largest being generally retained for preparing sizes above the usual requirements, and to these we shall have cause to refer again.

The smaller pieces are subjected to the next operation in order to prepare such articles as plates, prisms, discs, etc., the individual weight of which does not exceed a few pounds.

Molding.—All the favorable rough lump glass is subjected to this operation, which consists of gradually raising the temperature until it becomes plastic, and then by suitable tools giving to the pieces the shape required. As each article is molded it is passed into a separate kiln, where the final annealing is carried out, extending over a period of about ten days for ordinary sized plates.

The final annealing process increases according to the size and shape of the objects in hand; in fact, in some cases it is spread over a period of several months.

Examining the Glass.—The glass cannot be satisfactorily examined until the whole of the forementioned operations have been completed. Plates are polished on two opposite edges, small discs on four facets, prisms on two or more flat surfaces, in order to select the good material from the defective. Very much glass is at this point found unsalable; in fact, a yield of 20 per cent from any particular pot is considered satisfactory.

The defects which cause rejection may be divided into two classes: (1) Those which cannot be removed by a subsequent operation, i. e., bubbles (sometimes called seed), striæ, stones. (2) Those which can be removed by a subsequent operation—stresses.

CLASS I.

Bubbles.—The interactions which take place during the melting operations in some cases liberate as much as two hundredweights of gas per pot of glass, so that no further explanation is needed to indicate the source of this defect, and although the bulk of this is readily removed, yet the last traces are often troublesome.

Now, in order to perfectly free the glass from bubbles, it is essential to raise the temperature above a certain minimum, when the combined effect of fluidity and gaseous expansion renders it possible. Certain of the glasses (notably those containing large quantities of barium oxide) appear to be impossible of production free from fine seed, which has been explained by assuming that the glass at high temperatures continues to give off bubbles. To these special cases the optician and his client have become accustomed, but excluding these the demand is in general for perfectly seed-free material, and I have no doubt the optician is guided more or less by his clients' objection to the appearance of seed, imagining it to be a very serious defect, but when one takes into account that even in extreme cases the loss of light only amounts to 1/5,000th, it becomes practically negligible.

Perfectly bubble-free glass does not of necessity mean a better glass except in appearance, because the high temperature needed facilitates the attack on the fireclay of the pot, which increases the impurities taken up, thus increasing the light absorption value slightly, and rendering the perfect mixing by stirring more difficult.

* *Transactions*, of the Optical Society, London.

This latter point would suggest that in bubble-free glass there is a greater possibility for cases of want of homogeneity to occur—a point that is worthy of consideration.

Striae (*Veins*).—This defect is produced during the melting operation, and is the cause which necessitates the rejection of the major portion of the glass made. The two terms are used to describe the same defect, although the term "veins" is generally reserved to describe heavy striæ. The most important source of striæ is the action of the fluid glass on the fireclay pot during melting, being threads rich in silicate of alumina, although volatilization of certain materials during the time the glass is maintained at a high temperature is a contributing source. Borate glasses are prone to carry striæ as boric acid is freely volatilized from glasses which contain it. This loss of a constituent at a particular point produces layers of slightly varying refraction, which can only be overcome and completely incorporated by stirring.

The presence of striæ is described as want of homogeneity, which is undoubtedly correct, but this term is more comprehensive when used by the optician. He calls striæ "striæ," or may be "veins," but reserves the term "want of homogeneity" for something less than visible striæ, which produces a deformation of image. It is probably caused by a gradual index change due to the fact that although the striæ have been broken, they are invisible, yet have not quite reached the perfect state of incorporation.

Very heavy striæ may be easily seen by the unaided eye.

"Want of homogeneity," which is somewhat rare, can only be detected when other possible causes, such as curves, stresses, etc., have been eliminated.

The method by which these defects may be minimized is by adequate stirring, but on account of their method of formation it is doubtful whether they can be entirely eliminated.

Stones or Solid Bodies.—These do not in a great measure trouble the optician, owing to the fact that they are avoided as far as possible, and portions containing them rejected during the sorting operation.

They may consist of undissolved particles, but more frequently result from small pieces of clay leaving the pot and remaining suspended in the glass when too high a temperature has been reached. They continue to dissolve as they are in suspension, but this process is very slow, due in a measure to the viscous envelope which surrounds them. During stirring this envelope becomes elongated, and from each stone a tail-like filament identical with a vein is produced. This defect is very serious, and whole pots of glass are rendered useless, should it occur to any extent.

CLASS II.

The effect of stress on glass has been fully investigated by Pockels, proving that the change of index with uniform compression increases rapidly with the original density and index. Glass is a poor conductor of heat, and if such a body is cooled down from above its softening point rapidly, *stresses* are induced, depending on the rate of cooling. The body first solidifies on the outside, and being very rigid, will not allow the hot fluid interior to contract to its full amount; thus such a system should be under compresson near the sides and tension at the center, and a varying refraction must result. I have here two glass spheres of about 4-inch diameter. They were made from fluid glass, but in the first case it was chilled by allowing to cool as rapidly as possible consistent with keeping it intact, while the other has been carefully annealed. The bubbles in the unannealed glass are seen to be very large in the center, gradually fading away toward the outer edge. In the annealed sample the bubbles are very small and of uniform size—about 1 millimeter in diameter.

No glass is perfectly free from strain, but that found in the highest qualities of optical glass is of negligible amount.

Glass in general is a very complicated substance, and it would be a difficult matter to assign a chemical formula to express its constitution. It, however, behaves so much like a solution that it must be considered as such, certainly in most cases. There is, however, a tendency in all glasses to depart from their glassy nature, depending on the chemical composition.

Most, if not all, of the glasses, if maintained just above their softening points for a considerable time, would lose their glassy nature and become very similar to porcelain, and advantage is taken of this fact in some cases.

This phenomenon is known as "devitrification," and opinions differ as to its exact nature; some consider the crystals to have an identical composition with the glass, while others conceive it to be a true crystalization of a chemical substance from the solution. As regards myself, I take the latter view. With the ordinary crown and flint glasses this tendency to devitrify is not very serious, but as the optical constants become what may be termed abnormal, the chemical composition is altered to meet the case.

The alteration of composition along a line generally means increasing the amount of one or more of the constituents in the solution, and the increasing concentration ultimately reaches a limit when the glass cannot be prevented from depositing crystals. This tendency to devitrification is in many cases the phenomenon which prevents what may appear a very useful series of glasses from being realized in practice.

Examples of devitrified material do not often appear in public, but I have a few examples which may be interesting to a number present.

LARGE BLANKS.

Earlier this evening, when speaking of the glass from a pot, I mentioned that the larger pieces were generally retained for work of unusual dimensions, and among these may be mentioned telescope discs, prisms or large plates.

The first stage in preparation is essentially the selection of a suitable lump of volume well above that needed for the finished product; in fact, two or three times as large, and before any work is justified no excessive number of defects should be seen in the rough blocks. This operation alone will usually eliminate a large number of blocks from any further work in the intended direction.

Assuming for a moment that a block has been selected, it is first essential to polish this on four faces at least in order to select any portion which may be defective for removal. Should any portion be found useless—and there are few large blocks in which this does not occur—it is as far as possible cut away.

The block is now subjected exactly as in the case of the smaller work to a moulding operation, either into a rectangular or octagonal plate, and again subjected to examination by polishing its edges. Any defects are again removed, and the moulding operation performed, followed by another examination. These may have to be repeated four or five times, and the risks of breakage not only in heating but in subsequent cooling are very great.

As soon as all the defects have been eliminated by successive grindings, the glass is moulded to circular form of correct diameter and thickness, and finally subjected to a very careful annealing operation. It will be seen that the difficulties involved in not only obtaining large blocks but in their subsequent manipulations are very great.

For specifying the refractive properties of a glass it is customary to use bright spectral lines which can easily be obtained from artificial sources.

The lines which are generally adopted are the red potassium line, the yellow sodium line, and the lines $H\alpha$, $H\beta$, $H\gamma$ of the hydrogen spectrum. Of these the sodium, $H\alpha$ $H\beta$, are identical with the Fraunhofer lines D, C and F in the solar spectrum. The wave lengths of these in tenth meters may be taken as:

A^1 (potassium)	7,677
C (hydrogen)	6,563
D (sodium)	5,893
F (hydrogen)	4,862
G^1 (hydrogen)	4,341

The characteristic quantities $n_A{}^1$, n_C, n_D, n_F, $n_G{}^1$, are spectrometrically determined for each melting, and from them are deduced the mean dispersion $(n_F - n_C)$, and the partial dispersions $(n_D - n_C,\ n_F - n_D,\ n_G{}^1 - n_F)$. One very important quantity is deduced from these figures, and is commonly known as ν. Its value is expressed by $\frac{n_D - 1}{n_F - n_C}$ and is often called the dispersive reciprocal, being an important factor in lens systems.

The theoretical and practical optician is the important person who makes the demand which must be met by glass manufacturers, and although today such possibilities as increasing the range of optical glasses appears very small, yet we shall find that ultimately the production of what we now term abnormal glasses will be successfully accomplished.

A Mechanism of Protection Against Bacterial Infection*

Rockefeller Institute for Medical Research, New York

By Carroll G. Bull

THE means employed by the animal body to rid itself of bacteria have been conceived to be of two kinds: those of disintegration or lysis, and those of cellular inclusion or phagocytosis.

According to the former, the bacteria are acted upon by certain constituents of the blood serum—amboceptor and complement—which dissolve them; and according to the latter they are englobed by white blood corpuscles which digest them.

As a matter of fact, the first process has been inferred, rather than demonstrated. It is true that in shed blood the dissolution by lysis has been observed, but not in the living body. But even in shed blood or its serum constituents the solution occurs only with a part of the pathogenic bacteria, of which B. typhosus may be taken as an example. Such bacteria as pneumococcus, streptococcus, etc., are not subject directly to this form of dissolution. Phagocytosis, on the other hand, is a more general phenomenon and applies to a wide variety of bacteria.

It has long been known that when bacteria are introduced into and later disappear from the blood, they are not eliminated by the organs of excretion, but are destroyed in the organs themselves. The problem at issue relates to the manner of the destruction.

The question should be considered with reference to two states of the animal body, namely, the unprotected or normal, and the protected or immune state.

Taking certain forms of pathogenic or disease producing bacteria, a study was made as to the manner of their disappearance in protected rabbits. The pneumococcus and typhoid bacillus may serve as examples. Protection was secured by the employment of immune sera. In the case of the pneumococci, the type of pneumococcus and immune serum must coincide. In the experiments a type I pneumococcus and corresponding serum were employed.

Protection Against Pneumococcus.—It has been shown that an active pneumococcus serum protects against a certain maximum quantity of pneumococcus culture, but that multiples of the serum do not protect equally against multiples of the culture. An effective culture of pneumococcus causes on inoculation fatal septicemia in the rabbit, followed by death in 24 to 48 hours or less. When an immune serum is employed, life may be saved or the surviving period merely prolonged.

The immediate effect of a serum injection is to cause the removal of the pneumoccocci from the circulating blood. This effect is produced in an incredibly short period of time—in a few minutes indeed. But the permanency of the removal depends in part on the quantity (or dose) of antiserum injected. Small doses of serum are more effective than large doses, and the former may be successful in saving life, while the latter are not.

The mechanism of the removal is as follows: when an immune serum is introduced into the blood of a rabbit suffering from pneumococcus septicemia, an almost immediate agglutination of the bacteria takes place. The larger the doses of the serum, within limits, the larger the size of the bacterial clumps that are found. The clumps are removed from the blood almost immediately by the organs—the spleen, liver, and bone marrow. What happens next is determined by the size of the clumps. If they are large, they cannot be ingested by phagocytes; hence they soon begin to multiply, and the bacteria reinvade the blood; if small, they are taken up by phagocytes and are digested. The animal succumbs on the one and survives on the other hand. Hence small doses of the serum causing smaller clumps may be more effective than large doses giving larger ones. No extra-phagocytic dissolution of the pneumococci seems to occur.

Protection Against the Typhoid Bacillus.—A similar mechanism operates in the rabbit inoculated with cultures of the typhoid bacillus. The typhoid bacilli, notwithstanding the fact that they are subject to serumlysis, are taken out of the blood by the organs after clumping, and the clumps are ingested by phagocytes which digest them.

Pathogenic and Non-pathogenic Bacteria.—Certain cultures of disease-producing bacteria are not, others are pathogenic for animals. The influenza bacillus appears in these two distinct varieties. When cultures by the non-pathogenic variety are injected into the circulation of rabbits, they are clumped and removed by the organs at once; when cultures of the pathogenic variety are inoculated, they are neither clumped nor removed. Hence a pathogenic effect may depend upon agglutinability of the bacteria—by the blood of normal or of immunized animals.

In other words, bacteria circulating in the blood are quickly removed when they are agglutinated or clumped, and the clumps deposited within the organs are taken up by phagocytes and digested. They appear not to be destroyed by solution or lysis through the operation of serum constituents of the blood.

* *Proceedings* of the National Academy of Sciences.

Hard Paper Insulators

A METHOD of making paper insulators for electrical work was recently described in a German publication, and consists in impregnating suitable paper with resin, and then rolling the layers of paper together under pressure and heat. The ordinary resins first used softened at a comparatively low temperature, but where synthetic resins were substituted temperatures of 200 degrees produced no bad effect.

Plates of the material are easily made, and also cylinders, which are rolled on a kind of mandrel. The forms suitable for porcelain are undesirable with the new material; and although it can indeed be worked on the lathe, this requires time and costs money.

Winter in the mountains of California. One-story building nearly buried.

The Region of the Greatest Snowfall*

Facts, Conditions and Statistics of General Interest

By Andrew H. Palmer, Assistant Observer

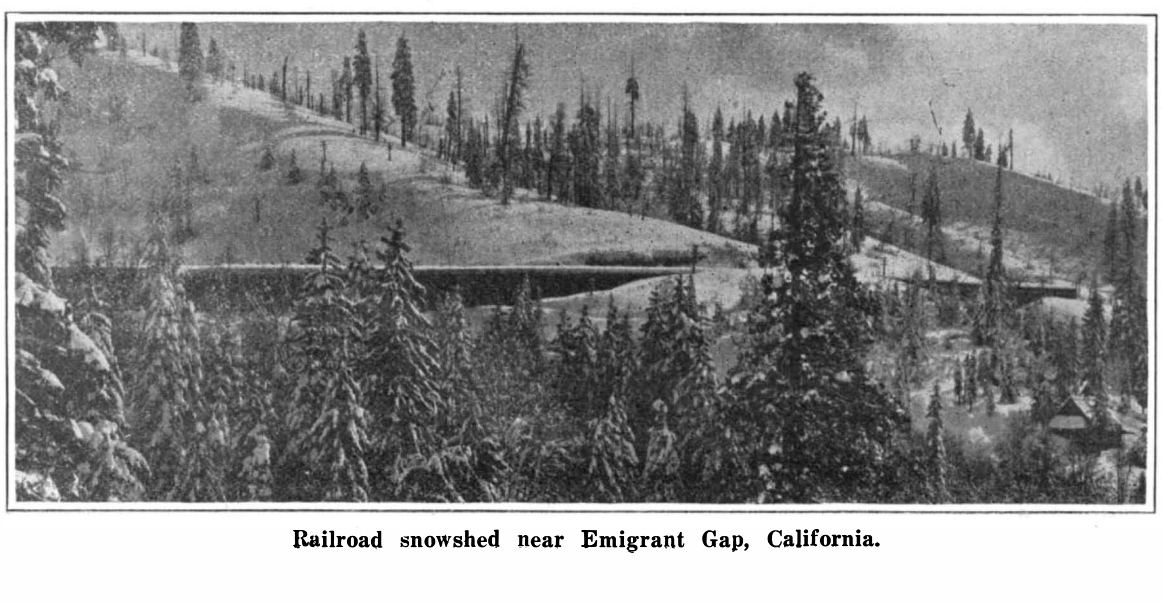
CALIFORNIA, usually thought of as a land of fruit, sunshine, and flowers, also has within its borders the region of greatest snowfall in the United States. The apparent anomaly is explained by the fact that this State (second in size in the Union) is an empire in itself. Variety is the keynote in all of its physical features, and extreme variety is noticeable in the climate of its various parts. For example, during the year 1913 a temperature of — 21 deg. Fahr. was recorded at Alturas on January 23rd, while a temperature of + 134 deg. Fahr. occurred at Greeland Ranch on July 10th. Moreover, during that same year no measurable amount of rain occurred at Bagdad, Cal., while in the northern part of the State 100 inches of precipitation occurred. Twelve regular and 235 co-operative stations of the United States Weather Bureau are now in operation within the State of California. They extend vertically from Mecca, 185 feet below sea level, to Bishop Creek, 8,500 feet above sea level. It is doubtful if any other State can afford a variety of climatological data equal to that recorded at these stations.

Though there may be a greater average seasonal snowfall in some of the uninhabited and unstudied portions of the United States, the records obtained in the high Sierra Nevada of California have not been exceeded. Particularly is this true of the region adjacent to the line of the Southern Pacific Railroad, which connects Sacramento, Cal., with Reno, Nev. Throughout many square miles in the Sierras traversed by this line more than 100 inches of unmelted snow falls every winter, making it the region of heaviest known snowfall in the United States. The average seasonal snowfall and the average annual precipitation for nineteen of the co-operative stations located in this region of excessive snowfall are given in Table 1.

*Abridged from a paper in *The Monthly Weather Review*, May 1915.

Beautiful effect of a heavy snowfall.

While the summers are relatively dry and the winters relatively wet throughout the State of California, the seasonal periodicity is less marked in the mountains than elsewhere. It is apparent from the table that up to a certain height there is an increase in the total annual precipitation with increase of elevation. It should be added that these mountains, though regions of heavy rainfall and excessive snowfall, are not perpetually covered with snow. On the highest peaks the snow disappears in May or June, and usually does not reappear until October.



Railroad snowshed near Emigrant Gap, California.

TABLE 1.—*Average seasonal snowfall and average annual precipitation at high stations in northern California.*

Station.	County.	Watershed.	Feet above sea level.	Number of years' record.	Average seasonal snowfall.	Average annual precipitation.
					In.	*In.*
Bishop Creek	Inyo	Mountain lakes	8,500	5	167.7	......
Blue Canyon	Placer	Sacramento	4,695	14	207.2	74.2
Boca	Nevada	Mountain lakes	5,531	29	151.5	20.8
Bowmans Dam	do	Sacramento	5,500	17	272.7	75.6
Cisco	Placer	do	5,939	33	370.0	52.0
Crockers	Tuolumne	San Joaquin	4,452	4	113.2	55.0
Emigrant Gap	Placer	Sacramento	5,230	29	282.7	......
Fordyce Dam	Nevada	do	6,500	16	402.4	72.4
Greenville	Plumas	do	3,600	18	100.2	44.0
Lake Eleanor	Tuolumne	San Joaquin	4,700	5	158.6	......
Lake Spaulding	Nevada	Sacramento	4,600	17	223.5	78.5
La Porte	Plumas	do	5,000	17	284.3	89.2
Quincy	do	do	3,400	18	76.6	48.4
Summerdale	Mariposa	San Joaquin	5,270	13	141.9	55.1
Summit	Placer	Sacramento	7,017	44	419.6	48.1
Susanville	Lassen	Mountain lakes	4,195	22	78.7	21.8
Tamarack	Alpine	San Joaquin	8,000	8	521.3	57.5
Truckee	Nevada	Mountain lakes	5,819	35	195.1	27.1
Yosemite	Mariposa	San Joaquin	3,945	8	106.9	38.6

If the records of a single station for one winter are considered, it is doubtful if greater seasonal snowfalls have been recorded in this country than those presented in Table 2.

TABLE 2.—*Some maximum winter snowfalls.*

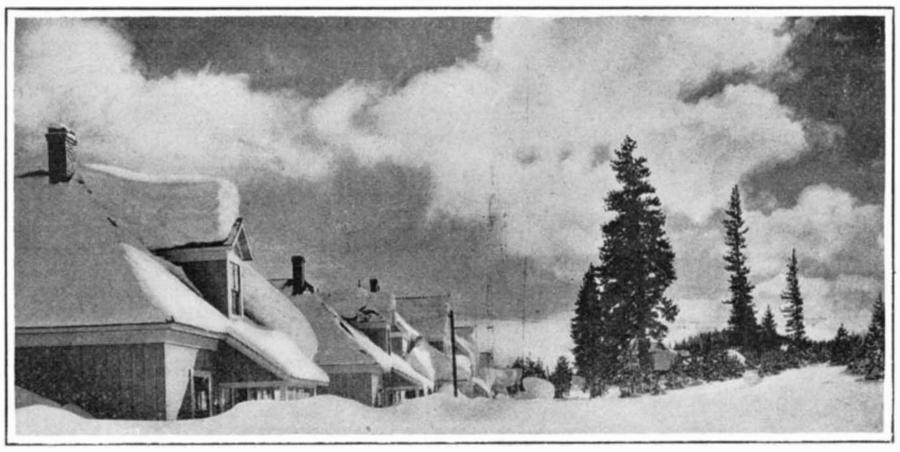
Place.	Winter.	Depths.		
		Inches.	*Feet.*	*Meters.*
Summit, Cal. (Donner post office)	1879–80	783	65.25	19.89
Do.	1889–90	776	64.66	19.71
Tamarack, Cal.	1910–11	757	63.08	19.23

To the average reader the enormity of these figures is perhaps best realized when he translates them into feet. Partly because of the length of the record and partly because of the extreme depth of snow, the seasonal snowfall for Summit, Cal., for a period of forty-four years is reproduced herewith in Table 3. An idea

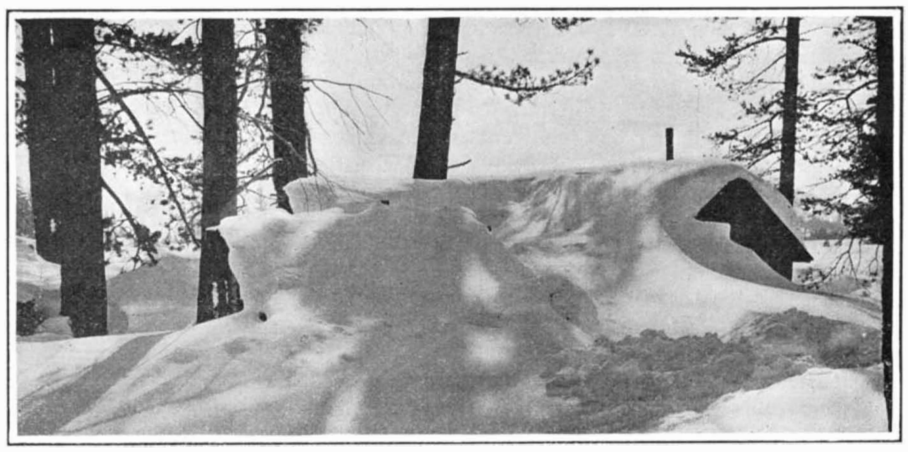
TABLE 3.—*Seasonal snowfall at Summit, Cal.*

[Lat., 39° 19′ N.; long., 120° 10′ W. Elevation, 7,017 feet.]

Winter.	Snowfall.	Winter.	Snowfall.	Winter.	Snowfall.
	Inches.		*Inches.*		*Inches.*
1870–71	300	1885–86	462	1900–1901	440
1871–72	550	1886–87	422	1901– 2	373
1872–73	334	1887–88	345	1902– 3	407
1873–74	200	1888–89	261	1903– 4	434
1874–75	284	1889–90	776	1904– 5	375
1875–76	525	1890–91	335	1905– 6	514
1876–77	178	1891–92	380	1906– 7	602
1877–78	341	1892–93	634	1907– 8	340
1878–79	446	1893–94	511	1908– 9	442
1879–80	783	1894–95	685	1909–10	342
1880–81	154	1895–96	544	1910–11	563
1881–82	492	1896–97	560	1911–12	277
1882–83	299	1897–98	262	1912–13	284
1883–84	482	1898–99	481	1913–14	437
1884–85	202	1899–1900	406		
				Average	419.6



Street scene in Hobart Mills in winter.



Lost in the drifts.

of the winter landscape at Summit may be had from one of the pictures.

Furnishing, as it does, most of the water that is used for irrigation purposes in California, the snow of the high Sierras is sometimes aptly referred to as the life blood of the State. The farmer is greatly interested because he wishes to know in advance how much water there is available to grow the coming season's crops. The hydraulic engineer, using water for power purposes, is interested for obvious reasons. The hydraulic miner also was until recently interested in the amount of snow. The railroad engineer, concerned with the maintenance of way, is also involved, as the task of keeping a track clear under conditions of such excessive snowfall is not an easy one. To the average visitor to this region, however, the amount of snow on the ground is a most impressive sight. Based upon the records of the past nine years, the average amount of snow on the ground at three selected stations is given in Table 4.

TABLE 4.—*Average amount of snow on ground at three California stations on the dates mentioned.*

Dates.	Fordyce dam (6,500 ft.).	Summit (7,017 ft.).	Tamarack (8,000 ft.).
	Inches.	*Inches.*	*Inches.*
Dec. 1	8	9	19
Dec. 15	27	29	40
Jan. 1	42	44	62
Jan. 15	76	82	113
Feb. 1	88	122	165
Feb. 15	94	126	173
Mar. 1	99	127	183
Mar. 15	100	140	194
Mar. 31	101	118	192

The accurate measurement of precipitation falling in the form of snow is an exceedingly difficult problem, and one which has not yet been satisfactorily solved.

However, the complete measurement of precipitation falling in the form of snow involves a measurement of the water content of the snow. Since the usually adopted ratio of 10 parts of snow being equivalent to 1 part of water is only occasionally true it is apparent that the fundamental problem is that of a proper "catch" of the snow in a suitable instrument. Its subsequent conservation and measurement is not a very difficult matter. The wind is the most troublesome of the disturbing factors. Regarding this problem, Prof. Marvin has laid down the following general propositions:

1. In calms and very light winds all gages of reasonable form and dimensions and in similar locations catch sensibly true and equal depths of precipitation.

2. In moderate, brisk, and high winds the catch of gages not screened or protected becomes more and more deficient with the increase in the force of the wind.

3. The deficit in catch due to wind is greater for snow than for rain.

4. In collecting *rain* the deficit in catch, even in strong winds, can be reduced to a relatively small percentage by the use of appropriate windshields, fences, and other protective barriers, such as have been successfully employed by Nipher, Hellmann, and others.

5. Additional careful experimentation is needed to perfect and improve windshields and to demonstrate that gages so protected collect snow satisfactorily on windy occasions.

At Blue Canyon and at Summit the Marvin shielded rain-and-snow-gage has been in use for several years. In this instrument, which is 9 feet in height, the collector consists of a cylindrical can, 40 inches deep by 10.85 inches inside diameter, around the mouth of which there is a double arrangement of windshields. To make a measurement the collector is hung upon a

Puzzle: Find the locomotive.

spring balance whose dial has been altered to read directly in inches and hundredths of water (or melted snow), a tare allowance being made for the empty collector. At Blue Canyon the gage has given reasonably satisfactory results, the only difficulty experienced being due to the fact that wet, sticky snow sometimes adheres to the inside top portion of the collector. On one occasion during the past winter a sheet of frozen snow formed completely across the mouth of the collector, while on six other occasions there formed an annular sheet of such width that the "catch" was appreciably deficient. At Summit, on the other hand, the gage, even though constructed in the massive proportions given above, has proved inadequate properly to measure the excessive snowfall. There snow accumulates on the ground to a depth of 20 feet almost every winter; on March 10th, 1911, 25 feet 7 inches of snow covered the ground. The measurements are made on level ground, and are not in drifts or banks. It is apparent that a gage of huge proportions is demanded in snow of so great a depth.

The density rather than the depth of the snow is, after all, the important matter. The water content, both of newly fallen snow and of that on the ground at any one time, is the information desired by most people. For new snow the Marvin shielded gage, referred to above, is perhaps the most satisfactory instrument yet devised. For determining from time to time the water available in snow remaining on the ground many and various methods have been tried.

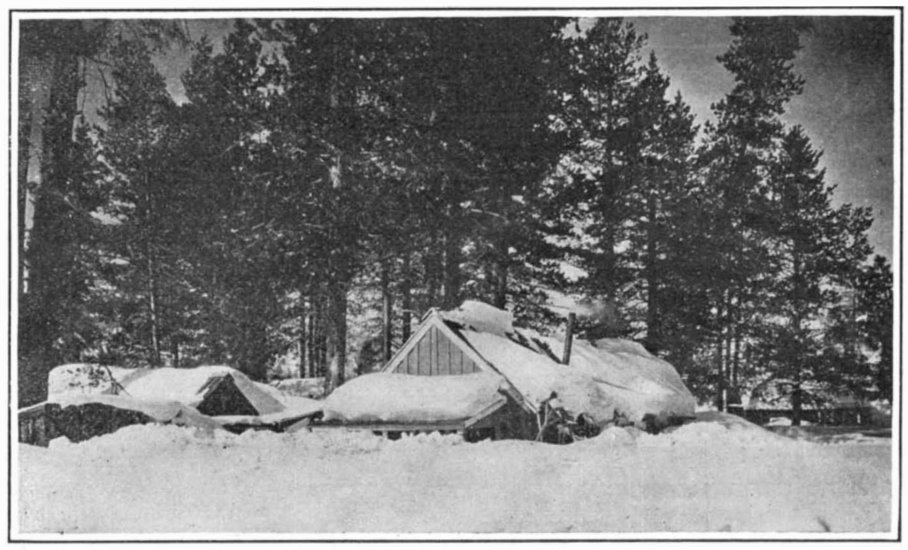
Investigators agree that a desirable method is to carefully weigh an accurately measured volume. Mr. G. H. Willson, section director for California, has long been of the opinion that the best method of determining the water available in snow on the ground is to secure the mean weight of a cubic foot of snow throughout a vertical section of the snow cover. His conclusions have the hearty approval of many engineers and other practical men interested in this problem. In theory the method is perfect. In practice, however, great difficulties are encountered, and the method is not recommended for general use. It is inapplicable when the snow is soft, the consistency of the snow rendering it impossible to get cubes. Moreover, in any kind of snow care is required to form perfect cubes, exactly one foot in every dimension, in order to produce reliable results. Furthermore, the method is exceedingly laborious, particularly when the snow is deep, and it often requires more time than the co-operative observes care to give to the work.

The method of measuring the weight of a pailful of snow, reading the density directly on a suitably marked spring balance, and then multiplying the depth of the layer by the density thus determined, has some advantages. But when the snow is deep and has within it ice strata or layers of varying density, as is frequently the case, considerable labor is involved in securing the true average density with the snow pail. The method of cutting out and measuring tubular sections has been used successfully by Prof. J. E. Church of the University of Nevada in extensive observations in the Sierras in snow 20 to 30 feet deep. Prof. Church introduced the use of the spring balance for effecting the measurements and otherwise improved the whole apparatus. In California there is a growing demand among mountain snowfall observers for some practicable, accurate method of measurement.

CONDITIONS ACCOMPANYING HEAVY SNOWFALL.

It might be contended that the data of heavy snowfall here given are based upon measurements made in

Winter scene near Truckee, California. Buildings nearly buried.



Snowbound. Note level surface and drifts.

canyons and gulches, where the wind has transported the snow, and the figures are therefore misleading. This is not true, however. During the past winter, at a time when 192 inches of snow covered the ground at Summit, eight measurements of the depth of snow on level ground at widely separated points on the mountains in the vicinity of the station were made, with the result that the depths varied only from 190 to 194 inches—that is, but 2 inches on each side of that at Summit. It should also be stated that, as its name indicates, Summit is located at the very apex of the mountains, at the highest point on this branch of the Southern Pacific Railroad. While the exposure is not exactly that of a peak, there is no point in the vicinity more than a few hundred feet higher than the level plot where the snow measurements are made. As a matter of fact the winds at these elevated stations are always relatively light and are in marked contrast with velocities recorded at high stations in the northeastern part of the United States. Based upon the 3 P. M. (Pacific time) observations telegraphed daily to the San Francisco office, the air at Summit was absolutely calm on forty-four of the ninety days, or 49 per cent of the time constituting the first three months of 1915. The extremely high wind velocities which often occur in winter in the White Mountains of New Hampshire are unknown in the Sierra Nevada of California.

PRESSURE RESULTING FROM DEEP SNOW.

To one who has never observed snow of greater depth than 4 or 5 feet, the pressure exerted by a snow cover 15 to 25 feet in depth is almost beyond comprehension. One might naturally infer that the pressure sustained by any object submerged in the snow is simply that of a vertical section of the snow above it. While this may be true for freshly fallen snow of superficial depth it is not true for deep snow which has been deposited in installments and which has intermittently been subjected to freezing and thawing, as is the case in the high Sierras. The following examples of the tremendous pressure of deep snow will suffice: The Marvin shielded rain-and-snow-gage at Summit, though substantially constructed of steel and sheet iron, was found to be a complete wreck when it was dug out of the snow on March 4 last. At Blue Canyon a fence, recently built around the railway station, had for its horizontal bars some discarded locomotive boiler flues, 2 inches in diameter. These tubes, made of a good quality of steel, were about 8 feet in length. When the heavy snow came, the vertical pressure it exerted upon these horizontal bars was so great that they were bent to such an extent that they fell to the ground from their sockets in the wooden posts.

The great pressure exerted upon submerged objects by deep snow is worthy of further consideration. It appears that when the sun emerges after a heavy snowfall the surface stratum is partially melted, but freezes to a hard crust after sunset. As this process is repeated day after day and the snow decreases in depth, irregularities appearing on the surface show that the snow over most submerged objects melts less rapidly than elsewhere. Humps on the snow surface usually mark the positions of objects beneath. When freezing of the surface stratum follows the noonday thaw, the weight of the frozen crust is borne by the submerged object, not only the crust directly over it, but also that for many square feet in every direction. More snow falls and the increased weight must be borne by the object beneath. The process is repeated over and over again, and if the snow becomes sufficiently deep the submerged object is either crushed or forced to the ground. A vertical post deeply submerged in snow is in some respects like a toadstool in that it must sustain the weight of a large disk which rests horizontally upon the top of its vertical axis.

THE ECONOMICS OF DEEP SNOW.

It is readily apparent that snow of so great a depth as that which falls in the Sierra Nevada Mountains must profoundly affect the economics of that region. Of these influences the most interesting perhaps are those affecting the railroads and their operation. The Southern Pacific Company has found it necessary to construct 32 miles of snowsheds between Blue Canyon and Truckee, at a cost of $42,000 a mile over single track and $65,000 a mile over double track. On an average, $150,000 a year is spent for upkeep and renewals, the expenditure for 1914 having been $65,000 for repairs and $91,000 for renewals. The average life of a shed is 22 years. They are built of massive timbers and are designed to sustain snow 16 feet in depth. When the snow gets deeper than 16 feet it must be shoveled off by hand. At certain points where the railway is located along steep slopes thousands of tons of snow slide over the tops of the sheds every winter. At these places a kind of apron, technically known as a "backoff," 30 to 40 feet in length, is built on the upslope side of the shed in order that the snow may slide harmlessly over the top. Even though timber 12 inches by 14 inches in cross section were used in its construction, 48 feet of snowshed near Blue Canyon collapsed because of the weight of the snow on February 15th, 1915. The fire hazard is naturally great. Concrete snowsheds have been built on other railroads to offset the fire hazard, but their initial cost renders that form of construction almost prohibitive. One other feature of this region is noteworthy. Flat-roofed houses are conspicuous through their absence. The gables of all houses, and particularly dwellings, are built at sharp angles in order that the snow may slide off easily.

Oil-Mixed Portland Cement Concrete—II*

Notes on the Preparation and Use of a Valuable Building Material

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2091 Page 80, January 29, 1915

BASEMENT FLOORS.

A BASEMENT floor which will remain perfectly dry may be constructed at a cost but very slightly higher than that of the ordinary basement floor by the incorporation of a petroleum residuum oil with the ordinary concrete mixture. The following method of construction, using an oil-cement mixture, is suggested as one which will prevent the permeation of moisture even from a very wet subsoil.

It will be well, if the underlying soil is very wet, to lay a 6-inch foundation of sand, cinders, broken stone, or gravel, compacting these materials well by tamping. In addition, it will be of advantage to employ drain tiles in this porous foundation, leading them to a sewer if possible. On top of the foundations should be laid a 4-inch layer of concrete mixed in the proportions of one part of Portland cement, two and a half parts of sand, and five parts of broken stone or gravel. Before the concrete base has hardened, a top or wearing coat of mortar mixed in the proportions of one part of cement and two parts of sand or stone screenings, and containing 5 per cent of oil (2½ quarts per bag of cement) should be laid. This top coat, because of its non-absorbent character, will give perfect protection from underlying moisture, and moreover it will build a floor which will dry out very quickly after washing, since practically none of the washing water will be absorbed.

It might be thought that the addition of oil to the mortar wearing coat would tend to make the surface slippery. Such, however, is not the case; nor is the appearance very much different from that of an ordinary cement floor. Should joints be provided for expansion and contraction, it will be necessary to fill them with a good bituminous filler to prevent the entrance of water.

Many cellar floors now made of Portland cement concrete are giving trouble owing to the permeating moisture. They are continually damp and, owing in part to the constant evaporation from their surface, they are cold. Such a condition may be remedied by the application of an oil-mixed mortar coat to the surface of the old floor. Before attempting to lay the new wearing surface, the old floor sould be scrubbed thoroughly clean and should be made thoroughly wet. The bond between the old and the new work will be improved if the old surface be roughened with s stone hammer. A wash composed of one part of hydrochloric acid and five parts of water may be used to clean the surface. This will dissolve some of the cement from the old work, leaving the aggregate exposed. The acid solution should be left on not longer than half an hour, when it should be completely removed with clean water. The surface should then be brushed with a wire or stiff scrubbing brush to remove any particles of sand which may have become loosened because of the dissolving of the cement.

A mortar composed of one part of cement and two parts of sand and containing 5 per cent of oil will be sufficiently non-absorbent for the new wearing coat. To strengthen the bond it will be well to apply a wash of grout, made by mixing cement with water to the consistency of cream, before laying the oil-mixed mortar coat. For the ordinary basement floor a 1-inch layer of mortar will prove of sufficient thickness. It will be necessary to keep the new mortar damp for at least one week in order that it may attain its proper strength.

CELLAR WALLS.

The entrance of moisture through the walls is another common source of damp basements. The water pressure in the soil adjacent to the wall is very seldom of great magnitude, so that a material non-porous and at the same time impermeable under moderate pressures is the logical one to use for this type of construction.

A concrete mixture in the proportions of one part of cement, two and a half parts of sand, and five parts of gravel or broken stone, together with 10 per cent of oil based on the weight of cement in the mixture, should prove amply rich for most situations. A wall of these proportions, 12 inches thick and provided with a spread footing, will withstand a pressure of 6 feet of earth. When supported at the top by floor joists, a much thinner wall may be used with safety. A 6-inch wall 7 feet high may be used to withstand 6 feet of earth pressure. Generally speaking, such a thin wall should be reinforced by deformed steel rods spaced about 2 feet apart in both directions. Any of the many types of deformed bars, made especially for reinforcing, may be used with perfect results. Care should be taken that the earth is not filled in against the back of the wall for at least four weeks after pouring the concrete, unless the wall is braced on the inside by allowing the inner forms to remain in place.

Many basement walls now built of stone, brick, or concrete are giving trouble through leakage. The application of a plaster coat of oil-mixed mortar composed of one part of cement, two parts of sand, 5 per cent of oil, and enough water to form a rather stiff mortar, will prove an efficient remedy for this trouble. The surface to which this mortar is to be applied should be roughened with a stone hammer, if the old wall is of concrete, or the mortar joints should be raked out to a depth of half an inch from brick or masonry walls. The acid wash previously described should be applied to cleanse the surface thoroughly, after which the loose particles must be removed with a wire brush or a stiff bristles brush. It will be impossible to obtain a water-tight coating if it is applied while water is seeping through the wall. It will be well to wait for the dry season, when the ground water is reduced to its lowest level, before attempting to waterproof by plastering. Should water appear to be coming through a well-defined crack in the wall, calking with oakum or cotton may be resorted to in order to stop the leakage until a plaster coat of oil-mixed mortar can be applied. It will be necessary to mix the mortar for plastering to a rather dry consistency, and it should be troweled hard in order to obtain a hard, dense waterproof surface. A wash of cement and water mixed to the consistency of thick cream and applied before the oil-mixed mortar coat is put on will aid the new mortar in adhering to the old work. The old wall must be thoroughly wet before the new mortar coat is applied.

WATERING TROUGHS.

The use of oil-mixed concrete in the construction of watering troughs will be found to give excellent results in maintaining them in an absolutely water-tight condition.

For this purpose a mixture of one part of Portland cement, two parts of clean coarse sand, and four parts of gravel ranging in size from ¼ inch to 1 inch is recommended. The mixture should likewise contain 10 per cent of oil based on the weight of cement and should be mixed to a jelly-like consistency. It will be well to provide wiremesh or steel-rod reinforcement for the bottom and walls. Care should be taken to puddle the concrete into place thoroughly and to trowel or spade the material next to the molds. This flushes the mortar to the surface, making it smooth and dense, and rendering a finishing coat of plaster unnecessary. Should a very smooth surface be desired, an effective finish may be obtained by applying several paint coats of oil-mixed cement grout made as follows: Enough water should be mixed with cement to form a paste of soft, putty-like consistency. To this paste should be added 3 per cent of oil, based on the weight of dry cement in the mixture (a 10-quart bucket of dry cement requires about a pint of oil for this purpose), and the whole should be mixed until the oil is entirely combined with the other ingredients. The paste may now be thinned down with more water to the consistency of cream, after which it may be applied with a stiff brush to the previously dampened concrete. A second coat of this oil grout should be

* Extracts from Bulletin 230, U S. Dept. of Agriculture, by Logan Waller Page, Director, Office of Public Roads.

applied after the first coat has hardened. Care should be taken that it does not dry out too quickly by applying it to the dry concrete or exposing it to the direct rays of the sun. A trough or tank built as described will be absolutely water-tight, and, furthermore, the waterproofing will have cost almost nothing in comparison with the cost of the other materials.

Cisterns.

For waterproofing cisterns, oil-mixed concrete will prove of great benefit. It is absolutely necessary that cisterns which are buried in the ground be waterproofed to prevent contaminated ground water from seeping in, as well as to prevent the cistern water from escaping. Buried cisterns of rectangular shape should be reinforced to resist the earth pressure, which tends to bulge the side walls inward when the water runs low. The reinforcement should, therefore, be provided on the inside or tension side of the walls. The earth pressure will prevent the tank from cracking when it is full of water.

For cistern construction a mixture composed of one part of cement, two parts of sand and four parts of gravel or broken stone, together with 10 per cent of oil, is effective. The inner faces of the cistern should be painted with an oil-mixed cement grout applied with a stiff brush and rubbed well into the face of the wall. Two coats of grout, containing about 3 per cent of oil, may be used.

Barns.

Barns constructed of concrete are gradually coming into use because of their durability, cleanliness, resistance to fire and economy. It is essential that the interior of these structures be kept free from moisture, and for this reason it is well to waterproof the concrete mixture entering the side walls and flooring. The side walls, unless waterproofed, have a tendency during a long, beating rain to absorb and retain much moisture, and this moisture penetrates to the interior.

If oil in amount equal to 5 per cent of the weight of cement be mixed with the concrete used in the side walls, this damp condition of the interior becomes impossible, because the admixture of oil prevents the penetration of the moisture.

Barn floors should be waterproofed by the addition of oil as previously described. A damp-proof floor has the advantage of remaining dry and hence warmer, because there is no evaporation from the surface. It is likewise more sanitary than an ordinary concrete floor because of its non-absorbent character.

Concrete Blocks.

The use of concrete blocks in the building trade is yearly increasing. Much criticism has been heaped on the building block, and in many cases the criticism has been just. It is recognized that many concrete-block houses are damp, owing to the fact that the walls are very porous and absorb and retain much moisture after a heavy, beating rain. A building block generally need not be waterproofed against water pressure, but it should, however, be rendered proof against the permeation of water by absorption. The use of a small quantity of mineral oil in a concrete block renders it extremely non-absorbent, so that even after a hard rain there is no danger from damp walls. In a 1:2:4 mixture, 5 per cent of oil is a sufficient quantity to waterproof properly against absorption.

Roofs.

Portland cement mortar mixed with mineral oil and reinforced with steel-wire mesh may be advantageously used in the construction of roof slabs. These slabs could be assembled in place on the roof after they have attained sufficient hardness. Reinforced concrete tiles may also be advantageously made with Portland cement concrete mixed with a small percentage of mineral-oil residuum.

Stucco.

Portland cement stucco is widely used in the construction of many residences. This type of construction is economical, and, moreover, with it many beautiful effects are possible. The term "stucco" is given to the exterior finish coat, which may be applied to brick, stone, concrete, hollow tile or frame construction. According to the finish desired and the kind of surface to be covered, the stucco is applied in two or three coats. The first, or scratch coat, should be mixed in the proportions of one part of Portland cement and two parts of clean, coarse sand, with enough water to form a good stiff mortar. If 5 per cent of oil is added to this mixture, the scratch coat will be permanently waterproof. While this coat is still wet, it is roughened with a stick or trowel over the entire surface. The second coat, which may be of the same proportions, is plastered on after the first coat has set sufficiently to support it. The use of oil in this coat may be omitted and it may be given a rough-cast finish by using a trowel covered with burlap or carpet.

The second coat may also be applied by throwing it on with a wooden paddle. This produces a rough surface known as a slap-dash finish. A pebble-dash surface may be secured by using a wet mixture composed of one part cement and 3 parts pebbles one-fourth inch in diameter. This mixture is thrown on the second coat while it is still soft, and the result is a very pleasing surface. When a pebble-dash finish is used, the second coat, as well as the scratch coat, may be mixed with oil. In most constructions the second coat will be found superfluous, because a sufficiently thick coating is usually obtained from the first application of oil-mixed mortar.

When stucco is applied to stone or hollow tile, care should always be taken to have the surface well moistened or otherwise a great deal of water will be absorbed from the mortar coat, and so greatly weaken it and cause contraction cracks to form.

Irrigation Ditches.

The results of laboratory tests, previously referred to, which indicate that the presence of oil tends to retard very materially the action of alkalies on concrete, suggests that another field for the use of oil-cement concrete may be found in the construction of linings for irrigating canals and ditches. Many of these canals are in localities where the soil is strongly impregnated with alkali salts and where the water carried contains alkali in solution. The destructive action of alkali is undoubtedly due to the crystalization of the salts within the mass of the concrete, or the formation by chemical action of compounds of greater volume than the original salts, or to a combination of both of these actions.

As the admixture of oil will retard the absorption of water into the concrete, it should materially lengthen the life of the lining. In the mixing of concrete for this purpose it is, of course, necessary to avoid the use of either water or sand containing alkali.[1]

Concrete Base for Roadways.

The use of this material should also prove of value for damp-proofing the concrete base of roads against the action of ground water, which if allowed to pass through will tend to disintegrate the road surface. Such action as this is particularly noticeable with road surfaces such as asphalt, bituminous concrete, etc. Assuming the usual proportions for the concrete base, etc., 10 per cent of oil should prove sufficient for this purpose.

Engineering Constructions.

There are many important engineering constructions in which oil-mixed mortar or concrete may be advantageously employed. Among them may be mentioned aqueducts, buildings, burial vaults, boats, foundations, gutters, mausoleums, roofs, sewers, troughs, tanks and wells. In some constructions a coat of oil-mixed mortar is effective, while in others oil-mixed concrete may be used throughout.

It is confidently believed that, if carefully prepared oil-mixed concrete is used in structures of any kind requiring damp-proofing—and in such structures careful work is a very important factor in the result—there will be no difficulty experienced from leakage and the structures will have been damp-proofed at very little extra expense.

The Consumption of Shells*

THE magnitude of the consumption of ammunition in the present war has only been equalled in unexpectedness by the extent to which the contest has settled down to one of position fighting or trench warfare, particularly in the west of Europe and the Dardanelles. Before the outbreak of hostilities there were very few persons in any of the belligerent countries who had any idea that a great European war would involve an expenditure, quite apart from small arms ammunition, of millions of shells of both small and large calibres, as has been proved by the experience gained during the past twelve months. As is known, the principal cause of the enormous requirements in shells of the high-explosive nature is to be found in the difference between the manner in which the existing war is being conducted and that which governed land campaigns in the last great war, namely, in the Far East. Prior to August of last year, it had certainly been reckoned that in the event of a European conflagration, trench warfare or position fighting would take place at different parts of the scene of operations, but comparatively few people expected that the latest method, or rather the exceptional development of an old system, would extend over several hundred miles of front and occupy armies day after day and month after month. Among the exceptions in Germany was Count Schlieffen, to whose life's work a Teutonic military writer attributes the splendid equipment of the German army with heavy artillery and the grand organization for supplying the armies with ammunition. As far as small arms ammunition is concerned, the correspondent states that in the most sanguinary battle in the war of 1870-71 the third army corps used an average of 35 cartridges per man per day, and in the Russo-Japanese war the average was 170 for Russian infantrymen, although the figure was increased to 196 on one day in the battle near Mukden. In the case of field artillery, the average number of shells fired per gun in the battle in question in 1870-71 is given as 162 per day, whereas the Russians are credited with having fired an average of 504 shells per gun near Mukden in connection with the battle mentioned. But all these figures are dwarfed into insignificance when compared with the estimates of the expenditure of shells in the present contest. It was reported, for instance, four or five weeks ago that by means of the concentration of numerous batteries the Germans were able to throw 700,000 shells at the Russian armies on a given area in the East in an astonishingly short time, while a more recent Russian report attributed to the former a waste of 70,000 shells in four hours before they discovered that the positions forming the target had already been abandoned by the retiring Russians.

It is doubtless correct to assume that the figures that have just been quoted are more or less approximations to the actual expenditure in projectiles. Yet the great consumption of heavy ammunition on the part of the enemy has failed to give the Germans any advantage in the western area of the contest during the past nine months, and they have even had to concede some territory which they formerly occupied, owing to the improvements in the equipment of the Allies. The military correspondent of an Italian newspaper, who has apparently been permitted to make inquires in France, throws some light on the shell problem. Six years ago, he states, the stock of shells held in France averaged 700 per gun, whereas that for the German field guns is declared to have amounted to an average of 3000. At the beginning of the war the French estimated a daily expenditure of 13,500 shells; in May of the present year the computation had risen to 80,000 per day, and to 100,000 by the commencement of July; but even this number is considered to be totally inadequate for the purpose. An illustration of what can be accomplished by the concentration of high-explosive shell fire was afforded by the battle at Arras, where after 20,000 shells had been discharged in two hours over a front of about six miles, all the enemy trenches and wire entanglements were destroyed. It is repetitions of continuous and concentrated shell fire on a considerably larger scale, in conjunction with the much heavier British and French guns, which are requisite both for the purpose of economizing the lives of the Allied soldiers and of defeating the enemy.

The only questions for the immediate future relate to the provision of further guns and an inexhaustible supply of ammunition. On the one hand, Germany and Austria-Hungary have reached the limit of their producing capacity in these directions, apart from the stocks of old shells, which should be nearly consumed by the present time. The combined output of these two countries in steel may now be said to be at the rate of 14,000,000 tons per annum, although a considerable portion of the tonnage would be useless in connection with the manufacture of high-explosive shells. It is impossible to increase this production, and every future withdrawal of bodies of men from the blast furnaces and steel works will imply a reduction in the output and consequently a diminution in the number of shells that can be made. But so far no men have been called up from these works without the provision of substituted labor in so far as is shown by the monthly statistics issued by the Association of Iron and Steel Manufacturers—statistics which may or may not be prepared for external consumption as well as for domestic use. As already stated, however, the maximum limit in the output of shells may be considered to have been reached, and when further men are requisitioned for military service, as indeed they must be in order to replace wastage, the production of shells will begin to decline, notwithstanding the employment of female labor; while the growing scarcity, as is believed, of special qualities of iron ore will also play a prominent part. On the other hand, the great and unimpaired resources of Great Britain in pig iron and steel and the reduced output of France and Russia are quite equal to those of Germany and Austria, to say nothing of the sources of supply in the oversea Dominions and other countries. The French commenced the mobilization of industry in the service of the army as far back as the end of last October by first requisitioning the plant of the motor car works and then proceeding similarly with other works capable of producing shells or their component parts. It is exceedingly unfortunate that with our immensely greater resources we did not also simultaneously organize our works in a similar manner. But the past is gone and we must look to the future, where final success will be assured, on the one hand, by the gradual exhaustion of the enemy in men, and, on the other, by the unrestricted production of coal and iron and steel and by the organization now in progress of the manufacture of munitions on a scale unprecedented in the history of the world.

[1]More detailed information relative to the use of oil-cement concrete for this purpose may be secured by reference to *Bulletin* No. 126 of the Department of Agriculture.

* From *The Engineer.*

The Alternating Current Single-Phase Induction Motor

A Simple Explanation of How It Runs and Why It Runs

By A. E. Watson

WHAT makes a motor of this sort run? While the answer cannot be stated in a few words, a separate consideration of the various actions and reactions should be contributory in giving a fairly acceptable explanation. At first the situation appears beclouded from the reason that of two of the actions prominently involved, that of the transformer and of the generator, the former is quite incapable of producing rotation, while the other strongly opposes rotation. Yet curiously, the combination of these two, under favorable conditions, actually produces the vigorous rotation happily realized in this highly developed mechanism. Almost no limit of mathematical analysis accompanied with intricate vector diagrams has been devoted to an explanation and computation of the operation of this type of motor, certainly with results of great importance to the physicist and engineer, but rather bewildering to the ordinary reader and experimenter. As an alternative means of bringing out some of the proofs, simple graphical diagrams, based

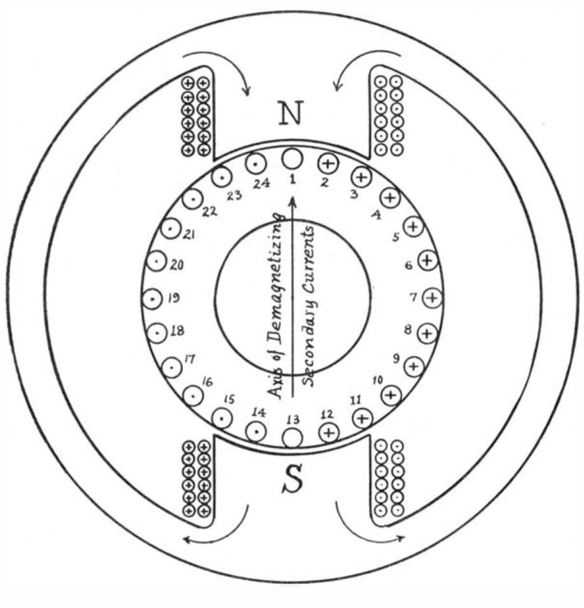


Fig. 1.—Transformer action. Armature stationary, field current increasing in strength from maximum negative to maximum positive value.

on the recognized behavior of electrical and magnetic forces, can frequently be made to turn invisible forces into almost material form, and contribute explanations entirely in harmony with principles already well in mind.

Whether dealing with direct or alternating currents, all electromagnetic actions are fundamentally the same; they are few in number, and a consideration of them singly and conjointly ought to lead to consistent explanation, whatever the particular machine concerned.

With alternating currents, perhaps the first thought is that of the transformer action; that a varying current in one coil will induce equivalent varying currents in a neighboring favorably arranged circuit, and that these secondary currents will always be flowing in closely the opposite direction to those in the primary. This means that while the primary current is always trying to establish or undo a certain magnetism, the other current is attempting to reverse these actions, a principle quite in keeping with Newton's third law of motion, that to every action there is opposed an equal and opposite reaction. It is worthy of note, too, that in the case of the alternating current transformer there is a closer realization of this numerical equality than in any other device yet invented.

To apply the transformer action to the case of the induction motor, reference can be made to Fig. 1, which represents an elementary two-pole field magnet, consisting, like the armature, of layers of thin sheet iron. By a common notation, currents flowing toward an observer are indicated by a dot on the conductor, like the point of an arrow, while a cross represents the tail of the arrow, or a current flowing from the observer. A particular direction of the current in a coil always produces a definite polarity, and the N and S poles, as marked, will prevail at the selected instant. A moment later, in consequence of the reversal of the current, the polarities will have exchanged. If now the page be turned upside down, so that the eye will look along from the N pole through armature to the S pole, and a mental picture be made of the spool of wire on each pole, the currents in them will be flowing in a clockwise direction. This is quite in agreement with accepted notation, commonly stated in the "corkscrew" rule. Perhaps in the case of an iron-clad or inclosed magnet, the application of this rule is not so obvious as with a straight bar magnet, but a little analysis will clear the point. Suppose, for illustration, a coil be placed on a gun barrel; if current flows in the coil in a clockwise direction, the muzzle will exhibit north polarity, while the breech will be south. In dynamo machinery straight magnets find little application, for the air path between the poles must be reduced to a minimum; so in the illustration, if something flexible, say a chain, be substituted for the gun barrel, and then the part corresponding to the breech end be brought around in front of the other end, the polarity would not be changed. So in the case at hand, the magnetic lines of force are emanating from the N pole and passing directly away from the observer through the intervening armature into the S pole beyond. Of course the return path is to be recognized, and that, too, is shown in the diagram.

The armature of the structure is represented as fitted with numerous round copper rods, electrically connected together at their ends, as is commonly observed in motors of this type. In order, however, not to interfere with the method of representing the directions of the currents in these rods, the end connections have not been shown. Conductors numbered 1-13 can be regarded as complete circuit, but no current will be generated in it by the changing magnetism, for lying edgewise to the magnetic flux it does not experience any change in that flux. Some magnetism will pass through the loops formed by conductors 2-12 and 24-14; loops 3-11 and 23-15 will receive still more, while the rest will be acted upon by nearly all the flux, therefore experience the largest currents. Complete circuits can now be imagined as arranged in quite a different manner, for a current flowing upward in conductor 24 can be regarded as returning in 2; 23 as belonging to 3, 22 to 4, and so on. Now as viewed from the lower edge of the page these currents will be exhibiting a clockwise direction of flow, therefore setting up a demagnetizing action. The direction of this axis clearly indicates that no notation is produced, for the two forces are directly opposed, as if there was an attempt to squeeze the armature into an elliptical shape. Or, in other words, if certain conductors are trying to produce rotation in one direction, an equal number is trying to produce the opposite rotation. Large currents will flow, soon destructive of the motor, quite like a transformer on short circuit. The direction of this demagnetizing axis, together with the observation that the largest currents flow in those conductors not directly under the poles, is to be compared with the next action, that of the generator, when rotation is actually introduced.

Fig. 2 represents the same structure with the field magnet energized as before, or even with a steady current, rotation by some external means having been imparted to the armature. If the reader will actually try the experiment, even with a small induction motor, energized with a battery current, he will find out how seriously the armature objects to being turned. The reason is that even at a low speed large currents will flow in the low resistance rods, quite like those resulting from the transformer action. The destructive nature of short circuits

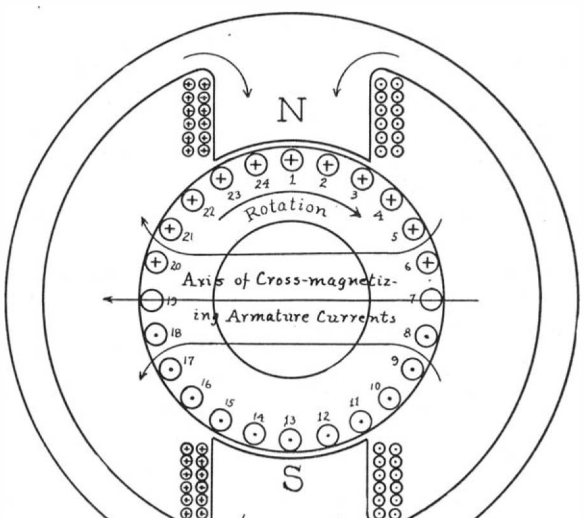


Fig. 2.—Generator action. Armature rotating, field current constant in direction, but not in strength.

in direct current machinery is well illustrated by this simple experiment.

With a definite direction of the rotation and a particular polarity of the field magnet a uniform direction of the induced current will always result. By Fleming's rule this is determined as follows: Let the fore finger of the right hand point in the direction of the lines of force, that is, from the N pole directly into the armature core; let the thumb, held at a right angle to the fore finger, point in the direction of the motion of that part of the armature core lying under the N pole; now the second finger, held at right angles to thumb and other finger, will indicate the direction of the induced current. To apply the rule conveniently in this case, turn the page upside down, so as to point the first finger as stated. Let the thumb be directly over conductors 1, 2, 3; it will indicate the clockwise direction in which they are moving; the second finger, pointing directly into conductor 1, indicates that in this and the neighboring rods

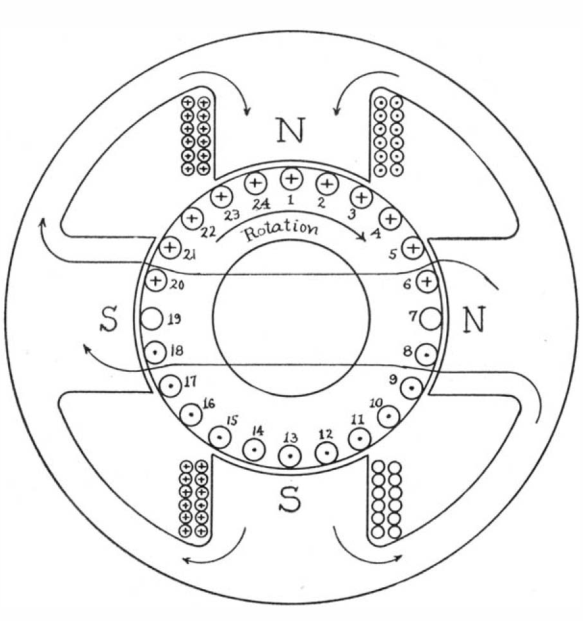


Fig. 3.—Generator action, with additional polar projections provided to encourage the establishment of the "cross" field.

currents are all flowing downward. By moving the hand toward the S pole, keeping the fore finger unchanged, but turning the wrist so as to point the thumb in the opposite direction, to conform to the direction of the motion of that part of the armature, the second finger will now point upward, showing that the currents in these rods will be flowing in the direction opposite to those in the former set. The conductors remote from the poles will experience no cutting of lines of magnetic force; therefore will be momentarily idle. In the diagram these are seen to be 6 and 19. Since the conductors are still electrically joined together, any desired grouping can be assigned. A current flowing upward in conductor 8 can be considered as flowing down by 6; one up in 9, down in 5; up in 10, down in 4, and so on. Now as viewed from the right hand face of the diagram this arrangement will constitute a clockwise flow of current in the cage of conductors, therefore a magnetic flux will be set up aimed away from the observer, meaning that an N pole will be on the farther side of armature, S on the nearer side. As indicated in the diagram, this constitutes a cross magnetizing action, always experienced in direct current machinery, interfering with good commutation, but in recent designs suppressed by use of interpoles fitted with counteracting windings. Curiously, in the type of alternating current motor now being considered, this cross magnetizing action is to be encouraged, for on its existence the only possibility of rotation is dependent.

In the first analysis, that of the transformer action, a current in a primary winding drove a magnetic flux across an air gap and induced secondary currents in the other winding, and this flow of secondary current will be produced whether the secondary structure be stationary or rotating. Of course in the second case, that of the generator, rotation is imperative, but if, in consequence of rotation, currents be produced, these dynamo currents, also alternating by virtue of the alternating field magnetism, can be regarded as new primary currents, and these can set up a flux of their own in the direction indicated in Fig. 2. By providing a path for this flux quite as good as that for the transformer action the new flux will be of almost equal strength. Fig. 3 shows how this is accom-

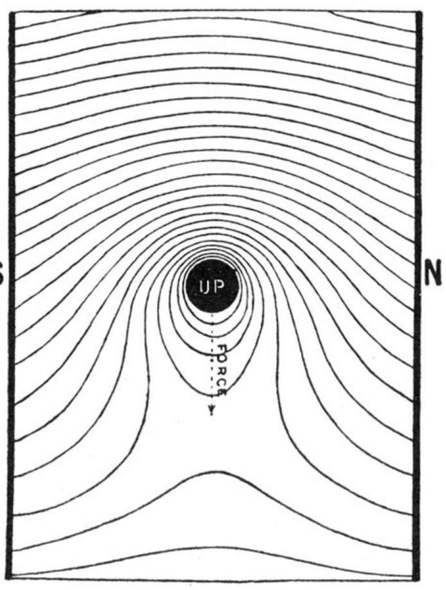


Fig. 5.—Magnetic lines due to conductor carrying current placed in magnetic field.

plished. Although now showing four polar projections, this structure is still to be regarded as essentially a 2-pole field magnet, quite in keeping with direct current phraseology, where the estimate is made on the basis of the main poles and not the interpoles.

It is certain that electric currents, quite like rivers, cannot flow in both directions at the same time. So the currents due to the transformer and generator actions must combine in some conductors, be eliminated or even reversed on certain others. Printed diagrams fail to interpret these rapidly varying conditions, for while directions of currents can be indicated by the use of dots and crosses, they cannot include the relative strengths of these currents nor follow in which conductors they are momentarily flowing. In order to include even an instantaneous representation of the merging of these currents and the result of the merging, a detour must be made to bring in two other factors, one involving the phase of the secondary current as regards that of the primary, the other the mechanical action between a current and a magnetic field.

One of the results of Faraday's classic experiments in electromagnetic induction was the disclosure that so long as currents were increasing in one coil, oppositely flowing currents were being induced in the neighboring circuit; that the mere direction of the current in the primary circuit was not the only consideration, but of equal importance was the factor as to whether the current was increasing or decreasing. Phase as well as strength was concerned. Instantaneous values of alternating currents are commonly represented by the ordinates, or altitudes, of a sine curve, as shown in Fig. 4. Intervals of time or momentary location of particular conductors are represented on the horizontal axis, values of current by the corresponding height of the curve. During the quarter period represented by *a-c* the current is increasing from zero to its maximum value; then it decreases, first at a slow rate, then much faster, to a second zero value; then it reverses and begins to increase in the opposite direction; at *f* the current is again momentarily steady. Now since the strengths of induced electromotive forces are dependent upon the rate of change of magnetic flux, for instance, as illustrated in case of a dynamo by its speed, it will be recognized that no electromotive force will be induced in a secondary circuit when the primary current has its maximum values, as at *c* or *f*, for a momentarily steady value will not be permitting any change in the magnetism. Though no electromotive force may be generated in a secondary winding by action of the primary, current may, however, continue to flow, due to the inertia effect known as inductance, and this effect is really present in induction motor operation. Except for this lagging quality, the condition holds that when the primary current has a maximum value there is zero secondary electromotive force; also, when the primary current is passing through a zero value it does so at a very rapid rate; therefore the associated magnetism is changing at a correspondingly rapid rate, and inducing in the secondary its greatest electromotive force. So, except for the lagging character of the secondary currents due to inductance there will be the largest currents in that circuit when there is no field magnetism. A diagram to include this lagging action cannot readily be brought into an elementary article. This vital difference between the transformer and the generator action is here to be clearly brought out, that whereas the greatest electromotive force is generated in a secondary circuit when the magnetism is zero, the maximum value of the electromotive force of a generator, as illustrated in a direct current dynamo, results when the magnetism is strongest. For as long a time then as it takes the field current to pass from its maximum negative value through its zero at *a* to its maximum positive value as indicated at *c*, currents will be flowing in the secondary conductors in one direction; from *c* to *f* in the other. For the generator, however, currents will be induced in the same rods in one direction for values and directions of the current shown between *a* and *e*, but in the other from *e* to *g*; for intermediate values, a negative secondary current will correspond to the point *b*; a positive current—in the direction of the now decreasing primary current—at the instant *d*; not having passed through the zero value, however, the magnetism though changing in strength has not experienced a change in polarity, so the generator or dynamo current continues to flow in unchanged direction.

At standstill of armature enormous currents can readily be induced by the transformer action, but of course at such a time there would be nothing expected from the generator action. At full speed, with corresponding direct current energizing the field, equally enormous dynamo currents would be generated, but with the field energized, as intended, with alternating currents, and the motor running at synchronous speed—when its alternations just coincide with those of the supply—one force just balances the other, and energy is neither received nor given out. By as much as the motor falls below synchronous speed the transformer action preponderates, and within certain limits, a useful rotational torque is developed.

A representation of the mechanical action between an

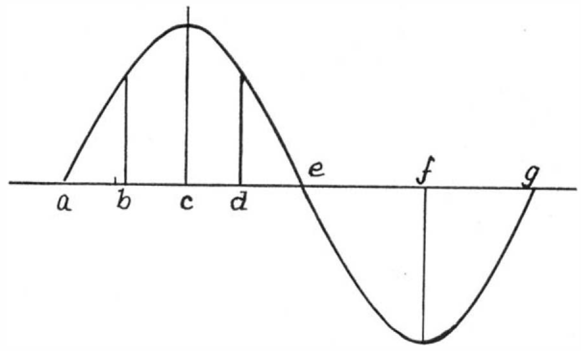


Fig. 4.—Representation of instantaneous values of an alternating current.

electric current and a magnetic field can be represented by the means shown in Fig. 5. By Maxwell's rule, a current flowing in a conductor away from the observer is surrounded by a clockwise whirl of magnetic lines; one toward the observer by a counter-clockwise whirl. Imagine such a wire placed between the poles of a magnet, as seen in Fig. 5. Since lines of force cannot cross each other, but must unite in resultant paths, this whirl around the wire strengthens the field flux above the wire, but annuls or weakens it at the bottom. Magnetic lines of force exert tension, known as magnetic pull, and as these lines try to straighten themselves out like rubber bands, the conductor will be urged in the direction of the arrow, not nearer to one pole than the other, not lengthwise, but equally away from both poles. Fleming's rule, now applied with the left hand, represents the action. Point with the fore finger from N to S pole, as indicating the direction of the magnetic flux; put the second finger in the direction of the current; the thumb will now give the direction of the sidewise motion urged upon the conductor. For convenience of applying the rule turn the page upside down. The fore finger will then lie horizontally, the second finger point directly toward the eye, and the thumb will point away from the observer. That this representation of the arrangement of the magnetic field is by no means fanciful may be seen from Fig. 6, which shows an actual distribution of iron filings around such a conductor in the air gap of a direct current motor.

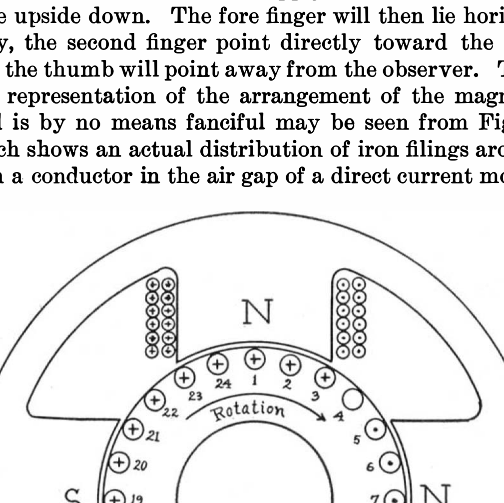


Fig. 7.—Transformer and generator actions combined; field current weakening, thereby reversing the transformer current, but not generator current. Regular motor action takes place under both auxiliary poles.

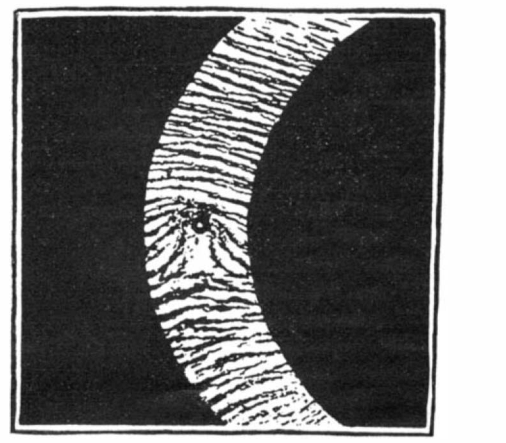


Fig. 6.—Actual magnetic field around conducting wire in dynamo air gap.

The movement will always be toward the magnetic "vacuum." It is this urging between magnetism and currents that produces the rotation in any electric motor; it is the restraining force which the prime mover must overcome in order to drive a generator.

With this motor principle established, it is seen that to produce clockwise rotation it is essential that currents flow upward under a north pole and downward under a south pole. Fig. 7 represents an instantaneous condition of the induction motor under rotation at considerable speed. Field current has just been increasing in value from zero to the maximum in the positive direction, between instants *a* and *c*, and is now decreasing in strength, say having reached the value shown at *d*. The secondary electromotive forces and currents will have reversed, but not those following the dynamo action, for the field, though lessening in strength, is of unchanged polarity. Consequently all the directions on the rotor rods shown in Fig. 1 are to be reversed and combined with those of Fig. 2, the result being shown in Fig. 7, where it is seen that currents are flowing up in conductors 5, 6, 7, 8 and 9 under the auxiliary N pole, and down in conductors 17, 18, 19, 20 and 21 under the auxiliary S pole, both sets contributing to produce clockwise rotation. That is, when rotation is started in a given direction, forces are immediately set into operation to encourage that rotation. This is illustrated by the fact that an induction motor can be started by hand. Currents will still be flowing in top and bottom conductors under the main poles in directions to oppose the rotation, and the operation of the motor is dependent upon the preponderance of the one force over the other. In this respect the case does not differ from that of the rotary converter, in which both generator and motor actions are always combined. Therefore within the working limits the desired preponderance holds, the motor absorbing more current as the load increases, until with too great a load the magnetic leakage along the air gap between stator and rotor permits the secondary currents to lag so much as to reduce their effectiveness. The motor then promptly "breaks down."

The summary of the action is that with motor at standstill, and having no special provisions for starting, the rotor will not start, however much current be sent through the stator windings, but by giving the rotor a start by any means in the desired direction, it will accelerate until nearly synchronous speed is attained. During this period of starting, the torque is very small, so little does the transformer action exceed that of the generator. As full speed is approached, the current drops to less than one half its starting value, yet yields greatly increased torque. The start can be made in either direction, and the motor will be as ready to run one way as the other. If special starting windings, however, are supplied, they must necessarily be connected for a particular direction, and once determined, the motor will always start in that direction.

A two-pole motor, such as is illustrated in the diagrams, would have a synchronous speed, when operating at 60 cycles, of 3,600 revolutions per minute, or on a 25-cycle circuit, of 1,500 revolutions. The actual speed under load will be somewhat less, dependent for one factor upon the ohmic resistance of the rotor rods, quite in keeping with the effect of resistance in the armature circuit of a direct current motor. In small sizes perhaps speeds of 3,300 and 1,400 revolutions, respectively, might be realized. For four-pole windings it will be seen that eight polar projections would really be required, but for purposes of introducing conveniently wound coils and getting a properly varying strength of magnetism—stronger in the center of the poles than at the edges—considerable subdivision of the winding is desirable, and twenty-four slots and coils are regarded as an acceptable minimum number. As a further step in this gradual tapering of the magnetism, no prominent gaps are allowed in the contour of the air gap between stator and rotor, therefore the openings for the coils and rods are made very narrow.

Other explanations of the operation of the single-phase

induction motor are frequently given, that due to Ferraris consisting of resolving the pulsating magnetism into two oppositely revolving fluxes, then showing that one of these produces the actual rotation of the armature, but that the other, in consequence of the double frequency of the induced currents, alternately helps and opposes the rotation, therefore rendering its average effect negligible. The mathematical treament then follows the usual procedure applied to two-phase and three-phase motors. Another method is to recognize that the magnetism in the auxiliary poles is established at an instant somewhat later than in the main poles. This means that a slight shifting of the effective magnetism takes place, the rotor rods are then cut by the flux, have currents induced in them, and are then dragged forcibly around. This too brings in the resemblance to the multiphase motor. Some physicists object to this conception of a shifting magnetism, claiming that waves, whether of magnetism or of anything else, possess up and down motion only, none in a lengthwise direction. The method of explanation given in this article involves only the well accepted principles of the transformer and dynamo machine, and these, in turn, are based on the fundamental relations between currents and magnetism.

Our Merchant Marine—II*

What It Has Been, What It Is and What It Ought to Be

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2091 Page 71, January 29, 1916

THE OCEAN MAIL LAW OF 1891.

FROM 1865 to the present time, Congress has refused to adopt any vigorous and comprehensive measure for the relief of American shipping in overseas commerce, though a cautious, and as it proved inadequate, mail subsidy system was established in the Ocean Mail Act of March 3rd, 1891. As passed by the Senate this provided both subsidies for postal lines and bounties for cargo vessels, but the bounty feature was rejected and the proposed mail rates were heavily reduced by Middle Western insistence in the House of Representatives. The legislation was so crippled that its authors despaired of any definite results, but even with its lowered compensation the Act of 1891 has proved to be of substantial value to the American merchant marine.

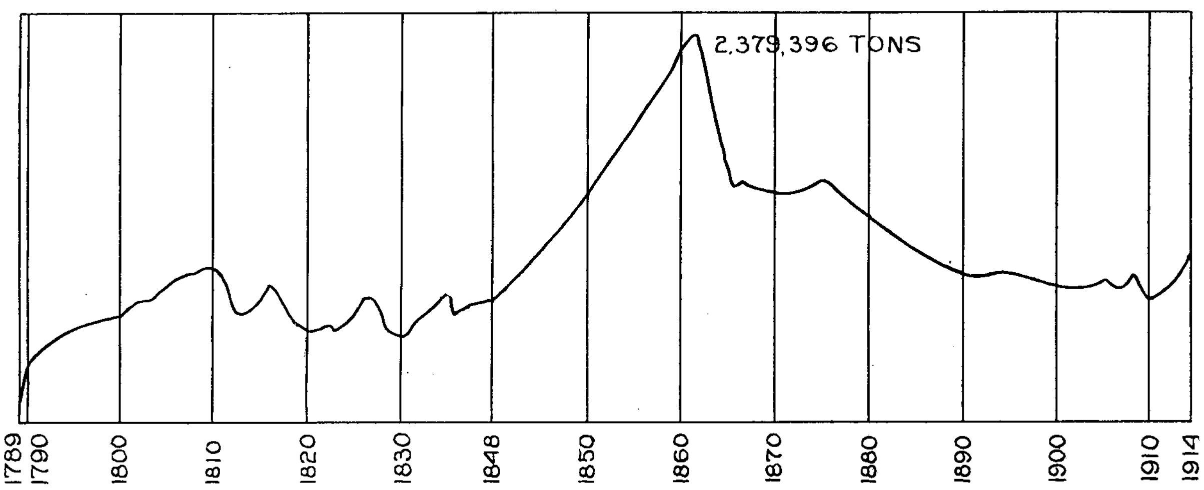
It was this legislation which made it possible for the International Navigation Company to undertake in 1895-1896 a weekly service in American steamships from New York to England and France, the "New York" and "Philadelphia" being specially admitted to American registry for this purpose, while the "St. Louis" and "St. Paul" were built in the Cramp shipyard in Philadelphia. These four swift ships were of great value as auxiliary cruisers in the Spanish war. Though the company controlling these steamers has several times signified its willingness to build new ships equal to the best on the Atlantic if the United States Government would enter into an agreement equivalent to that of Great Britain with the Cunard Company, no action has been had, but the weekly mail service to Europe is maintained with great regularity by the existing steamers, and this has been of much advantage to our Government and our merchants throughout the present war.

The Ocean Mail Act of 1891 maintains also the Ward Line of American steamers from New York to Cuba and Mexico, the Red D Line from New York to Venezuela and the Oceanic Line from San Francisco to Australasia. Total expenditures under this act in the fiscal year 1914 were $1,089,361, of which $673,998 was received by the American transatlantic service. Every great maritime nation spends much more for mail subsidies than our own—Canada two or three times as much.

THE MERCHANT MARINE COMMISSION OF 1904-1905.

Congress, in 1904, authorized a Merchant Marine Commission of five senators and five representatives, of which Senator Gallinger, of New Hampshire, was chairman, to make a new and thorough investigation of the ocean shipping question. This commission published its report in 1904-1905, recommending national encouragement to regular steamships services to the West Indies, South America, South Africa, Australasia and the Orient, and the granting of tonnage subsidies to cargo vessels. A bill carrying these provisions passed the Senate, but the subsidy to cargo ships was eliminated in the House and the mail subsidy measure which the House passed was defeated by a filibuster in the Senate, conducted by two senators who were retiring to private life. The Senate subsequently passed the ocean mail bill, but it was twice defeated in the House, though by the narrowest of majorities.

In the congressional contests over the measures recommended by the Merchant Marine Commission, most of the opposition came from the South and Middle West—thus repeating the experience which had destroyed the American steamship services on the North Atlantic before the civil war. But from both South and West there appeared also strong advocacy of a forward policy by individual senators and representatives, and the ocean mail bills were actually defeated in the House by the defection of a group of Middle Western Republicans who, though strong partisans of tariff protection for the agricultural interests of their States and section, were unwilling that national encouragement of any kind should be extended to the ocean shipping industry of the Atlantic and Pacific seaboards. Another influence was the hostility of certain powerful European steamship corporations which had become strongly entrenched in American ocean carrying. From their headquarters in Europe and New York these foreign steamship organizations sent out earnest arguments against the subsidizing of American steamship services, and these appeals undoubtedly counted for a great deal with some public men and people of European birth or immediate descent in this county, to whom they were addressed.



Curve showing American tonnage in foreign trade at various periods.

A FREE SHIP EXPERIMENT.

As a part of the Panama Canal Act of August 24th, 1912, Congress changed the traditional policy of the United States by offering free registry for the overseas trade to American-owned, foreign-built vessels not more than five years old. This "free ship" experiment proved absolutely fruitless up to the outbreak of the war in Europe—not one foreign-built ship was at any time registered under its provisions. The reason assigned was the higher cost of operation that would have to be assumed under American laws and colors.

As an emergency measure Congress, on August 18th, 1914, passed an act amending the previous act so that there could be admitted to American registry for purposes of foreign commerce American-owned, foreign-built vessels without regard to age. At the same time the President was authorized to suspend the requirement of law that the officers of these foreign-built ships should be American citizens, and to exempt the ships in question from compliance with our inspection and measurement laws and regulations.

A considerable movement of American owners of foreign-built ships to naturalize their vessels under the new law quickly followed. The United Fruit Company, the Standard Oil Company and the United States Steel Corporation were the principal factors to take advantage of the new legislation. Most of the foreign-built ships added to the American overseas fleet under the new policy were American-owned before the war began. There have not been many new purchases of foreign-built ships, and a very large proportion of vessels controlled by American capital, notably in the regular transatlantic trade, still remain under foreign colors. The total number of ships naturalized under the Act of August 18th, 1914, is 171 of a total tonnage of 583,733. Most of these were brought in in the early part of the war. Only three vessels, one of them a small yacht, were granted registry in the entire month of September, 1915, and only three more were admitted up to December 18th, 1915.

FOREIGN CREWS DEMAND AMERICAN WAGES.

It has been discovered in actual experience that the suspension of the navigation laws by the President, so that the foreign-built ships admitted to American registry can come in with their foreign officers and remain exempt from our inspection and measurement laws and rules, has not prevented these foreign officers and their foreign crews from demanding the wage scale and food scale of Americans. The result has been an immediate and large increase in the cost of manning and maintenance, so that in these regards the naturalized ships are on the same basis compared with foreign-registered ships as are American ships of native construction. For example, W. R. Grace & Co. find that wages and food of a steamship under the American flag amount to $2,773 a month as compared with $1,991 under the British flag. "On British steamers which we recently transferred to the American flag," says this firm, "the foreign crews struck for American wages the day of transfer and received them."

The United States Steel Products Company, which handles the export trade of the United States Steel Corporation, has nine steamers transferred from British to American registry. The 373 members of these nine crews under British registry received in wages $12,478 a month. The 393 members of these nine crews under American registry receive $17,537 a month—an increase of 40.54 per cent, and in addition there has been an increase of 19 per cent in the cost of food.

The steamship "Brindilla," of the Standard Oil Company, has a total wage bill under the American flag of $1,765 a month, as compared with $936.10 a month when this same ship was the German steamer "Washington."

These great corporations have precise systems of record, and so these comparative figures are available and trustworthy, but theirs has doubtless been the experience of all owners of foreign-built steamships who have secured American registry. The great war has introduced new complications. Because of war risks wages of seamen have risen under foreign flags, but there is every reason to believe that when the war has ended the normal difference in wages between American and foreign ships will be substantially what it was before the war began. This difference on typical cargo carrying ships was as follows:

COMPARATIVE WAGES, 1914, ON AMERICAN AND BRITISH CARGO STEAMERS OF A CAPACITY OF ABOUT 5,000 TONS.

	American. Wages per Month.	British. Wages per Month.
Master	$175	$100.00
First officer	90	63.18
Second officer	70	43.74
Third officer	60	.....
Carpenter	40	31.59
Boatswain	35	29.16
Quartermaster (2)	35	.....
Sailors (5)	30	(9) 24.30
Chief engineer	150	97.20
First assistant engineer	100	68.04
Second assistant engineer	90	48.60
Third assistant engineer	80	.....
Oilers (3)	40	.....
Donkey men (2)	40	(1) 31.59
Firemen (4)	35	(6) 29.16
Coal passers (2)	30	.....
Steward	60	38.88
Cook	45	34.02
Mess man	20	15.00
Cabin boy	20	.....

Total American crew, 32 men.
Total American payroll per month...............$1,655

Total British crew, 27 men.
Total British payroll per month.............$994,66.

* A report of a special committee of the Boston Chamber of Commerce.

AMERICAN TONNAGE AND PROPORTIONATE CARRYING IN FOREIGN TRADE OF UNITED STATES, 1789–1914.*

Year Ended Dec. 31.	Tonnage Registered for Foreign Trade. Tons.	Proportion of Exports and Imports Carried in American Vessels. Per Cent.	Year Ended Dec. 31.	Tonnage Registered for Foreign Trade. Tons.	Proportion of Imports and Exports carried in American Vessels. Per Cent.
1789	123,893	23.6	1821	593,825	88.7
1790	346,254	40.5	1822	582,701	88.4
1791	363,110	55.9	1823	600,003	89.9
1792	411,438	64.0	1824	636,807	91.2
1793	367,734	79.5	1825	665,409	92.3
1794	438,863	88.5	1826	696,221	92.5
1795	529,471	90.0	1827	701,517	90.9
1796	576,733	92.0	1828	757,998	88.9
1797	597,777	90.0	1829	592,859	89.5
1798	603,376	89.0	1830	537,563	89.9
1799	657,142	88.5	1831	538,136	86.5
1800	667,107	89.0	1832	614,121	83.1
1801	630,558	89.0	1833	648,869	83.8
1802	557,760	86.5	1834	749,378	83.0
1803	585,910	84.5	Sept. 30, 1835 (9 mos.)	788,173	84.5
1804	660,514	88.5	1836	753,094	84.3
1805	744,224	91.0	1837	683,205	82.6
1806	798,507	91.0	1838	702,962	84.2
1807	840,163	92.0	1839	702,400	84.3
1808	765,252	90.5	1840	762,838	82.9
1809	906,855	86.0	1841	788,398	83.3
1810	981,019	91.5	1842	832,746	82.3
1811	763,607	88.0	June 30, 1843 (9 mos.)	856,930	77.1
1812	758,636	82.5	1844	900,471	78.6
1813	672,700	68.0	1845	904,476	81.7
1814	674,633	54.5	1846	943,307	81.7
1815	824,295	74.0	1847	1,047,454	70.9
1816	800,760	70.5	1848	1,168,707	77.4
1817	804,851	76.5	1849	1,258,756	75.2
1818	589,944	82.5	1850	1,439,694	72.5
1819	581,230	84.5	1851	1,544,663	72.7
1820	583,657	89.5	1852	1,705,650	70.5

* Figures taken from the report of the Bureau of Navigation and Bureau of Foreign and Domestic Commerce of Department of Commerce.

WHAT SHOULD NOW BE DONE?

Assuming that the free registry law of August 18th, 1914, has the effect of equalizing the first cost of ships —for American ship-owners can now go to Europe or Japan for vessels for overseas commerce if such ships can be procured there at a lower price than from American yards—there manifestly still remains, in spite of the suspension of our navigation laws, a wide difference in wages and maintenance. Of the two factors in the problem the construction cost has been equalized, but not the cost of operation. This is still as heavily against our flag as ever—and this is now a matter of demonstrated fact; it has been wholly removed from the field of dispute and speculation.

How is this factor of the higher cost of operation to be met?

The Special Committee on Merchant Marine of the Boston Chamber of Commerce, in a report presented June 7th, 1915, and subsequently approved by the directors of the chamber, recommended that carefully guarded subsidies be granted by the Government, sufficient to offset the difference in cost of operation between American and foreign vessels, with the condition that all vessels receiving subsidies should be so constructed as to render efficient service as transports, fuel ships, supply ships, ammunition ships, etc., in case of war, and be held subject to the call of the Government.

This plan would equalize conditions so far as typical cargo vessels are concerned. But all maritime nations assist regular steamship services carrying mail, freight and passengers on fixed schedules at more than ordinary speed, by means of mail or naval subsidies, amounting in the aggregate to not much less than $50,000,000 a year. It is obvious that such regular line steamship services under the American flag would require special additional encouragement, and for this purpose the committee, in its report, recommended an amendment suitably increasing the rates of compensation offered under the Ocean Mail law of 1891.

The committee also opposed the proposal of Government ownership and operation of commercial steamships, for reasons stated in a separate report, and approved the creation of a Federal Shipping Board, after the example of the British Board of Trade, and a revision of our navigation laws and regulations, so far as they unnecessarily increase the cost of operation of American as against foreign vessels. Such a revision is an essential part of any movement for the revival of American ocean shipping, but, as has already been demonstrated by experience under the free registry act of August 18th, 1914, a revision or a suspension of the laws and regulations will not of itself equalize the cost of manning and maintaining American and foreign vessels.

SHIPBUILDING ALL-IMPORTANT.

At present, because of the great European war, its abnormal effect upon wages and materials and the absorption of foreign shipyards in naval repair and construction, the first cost of commercial steamships is believed to have risen in Europe to or near a parity with the cost in the United States. American ocean shipyards are now fully employed upon new tonnage, nearly all of it designed primarily for coastwise commerce, but a large part of it of a type adaptable also to overseas carrying, if conditions in that trade can be properly equalized. This is a fortunate circumstance for the country. Full employment will greatly assist American ocean yards to extend their experience, standardize their output and reduce their costs, and the price of commercial steamers of American construction should be very much nearer the foreign price after the war has ended than it ever has been before. It should be understood that steel plates and shapes for shipbuilding are normally obtainable at as low a cost in the United States as in Europe.

The importance of judicious encouragement of the art of ocean shipbuilding cannot well be overestimated, both because of the imperative need of well-equipped shipyards in the problem of national defense, and because history affords no example of a nation permanently great in ship-owning and navigation which depended for the construction of its ships upon its rivals in trade and possible enemies in war. It is still eminently true in principle, as Thomas Jefferson declared more than a century ago, that "For a navigating people to purchase its marine afloat would be a strange speculation. . . . Placing, as a reserve, with a foreign nation or in a foreign shipyard, the carpenters, blacksmiths, calkers, sailmakers and the vessels of a nation, would be a singular commercial combination. We must, therefore, build them for ourselves."

AMERICAN MARINE INSURANCE.

One essential of complete success in American shipbuilding and navigation is a thoroughly American inspection, survey and classification service, capable of performing for the United States a work which Lloyd's has long rendered for the British Empire. For many years American shipowners and merchants even in the coast and lake trade have been largely dependent for marine insurance upon foreign corporations. To realize the full benefits of an independent American shipping industry, it must be possible to effect adequate insurance in companies domiciled in the United States, preference being given by our shipowners and merchants to insurance in American companies, and to this end a strong classification society must be at once established, so that American insurance interests can undertake marine risks with all proper safeguards and necessary information. There is abundant capital in this country, and abundant technical and administrative skill, and they should be brought into effective co-operation. There should be resources in American companies sufficient to provide at least $1,000,000 of insurance on any single hull, to handle the marine business now offering, which is about three times the amount of insurance at present available.

Every important nation which has developed a merchant marine of its own has appreciated the need of creating at the same time a classification and insurance system of its own, instinctively recognizing the unwisdom of depending for such an indispensable service upon the resources of foreign competitors. It is earnestly believed by many American shipowners that the decline of our mercantile marine was hastened by certain arbitrary discriminations of powerful marine insurance authorities of Europe, and it is the manifest course of prudence to make such discriminations impossible hereafter by providing requisite American standards of construction properly adapted to meet the particular needs of the widely varying types of ships required for American domestic and foreign commerce. Private capital and enterprise can best supply this need, with due recognition in the laws and regulations of the Government.

A FLEET ESSENTIAL FOR COMMERCE AND DEFENSE.

The merchant marine—the building and operation of overseas commercial carriers—is, or should be, a great national industry, as deserving as any other great industry of the friendly interest of the American people and the intelligent consideration of their Government. Just as every adequate department store, for its own self-protection, insists upon its own delivery service, so every mercantile nation demands a suitable fleet of its own ships. Great Britain fought fierce wars with Holland and France primarily to secure its own sea trade. The new German Empire, when under Bismarck it first began to look abroad for markets, refused to depend upon British ships, but sought at once the creation of a German merchant navy. France would not rely upon the fleet of either Germany or Britain, but has laboriously wrought its own merchant marine, and Japan, the latest of commercial powers, secured its ships first and its trade afterward. Not one commercial nation—save the United States—has ever been willing to trust its overseas delivery service to its eager and

9 Months Ended June 30.	Tonnage Regis- for Foreign Trade. Tons.	Proportion of Exports and Imports Carried in American Vessels. Per Cent.	9 Months Ended June 30.	Tonnage Registered for Foreign Trade. Tons.	Proportion of Imports and Exports Carried in American Vessels. Per Cent.
1853	1,910,471	69.5	1884	1,276,972	17.2
1854	2,151,918	70.5	1885	1,262,814	15.3
1855	2,348,358	75.6	1886	1,088,041	15.5
1856	2,302,190	75.2	1887	989,412	14.3
1857	2,268,196	70.5	1888	919,302	14.0
1858	2,301,148	73.7	1889	999,619	14.3
1859	2,321,674	66.9	1890	928,062	12.9
1860	2,379,396	66.5	1891	988,719	12.5
1861	2,496,894	65.2	1892	977,624	12.3
1862	2,173,537	50.0	1893 (1 Year)	883,199	12.2
1863	1,926,886	41.4	1894	899,698	13.3
1864	1,486,749	27.5	1895	822,347	11.7
1865	1,518,350	27.7	1896	829,833	12.0
1866	1,387,756	32.2	1897	792,870	11.0
1867	1,515,648	33.9	1898	726,213	9.3
1868	1,487,246	35.1	1899	837,229	8.9
1869	1,496,220	33.1	1900	816,795	9.3
1870	1,448,846	35.6	1901	879,595	8.2
1871	1,363,652	31.9	1902	873,235	8.8
1872	1,359,040	29.2	1903	879,264	9.1
1873	1,378,533	26.4	1904	888,628	10.3
1874	1,389,815	27.2	1905	943,750	12.1
1875	1,515,598	26.1	1906	928,466	12.0
1876	1,553,705	27.7	1907	861,466	10.6
1877	1,570,600	26.9	1908	930,413	9.8
1878	1,589,348	26.3	1909	878,523	9.5
1879	1,451,506	23.0	1910	782,517	8.7
1880	1,314,402	17.4	1911	863,495	8.7
1881	1,297,035	16.5	1912	923,225	9.4
1882	1,259,492	15.8	1913	1,019,165	8.9
1883	1,269,681	16.0	1914	1,066,288	8.6

aggressive competitors—the instinct of self-preservation imperatively forbids.

If the United States had possessed, as it should normally have possessed, 10,000,000 or 15,000,000 tons of overseas shipping in August, 1914, at the outbreak of the present European war, its ocean delivery service could not have been broken down by the wholesale diversion of foreign ships whose first duty was owed to foreign governments. Reduced or disrupted steamship services and abnormally increased freight rates have cost the American people uncounted millions of dollars since the war began, and as agriculture still supplies the major bulk if not the major value of our exports, the heaviest loss has fallen upon the cotton-growing South and grain-growing West, many of whose public men have historically been most blind and indifferent to the need of a merchant fleet that would serve "America first."

If an adequate merchant shipping is important to our commercial security it is absolutely indispensable to our military and naval defense. In the event of war between the United States and a foreign enemy our Government would instantly require hundreds of auxiliary vessels, scouts, transports, mine layers, fuel ships, ammunition ships, supply ships, hospital ships—which could be provided only from the merchant service. Many of these can be procured from the coastwise fleet, but not enough, for a large part of this domestic tonnage is not adapted to open-ocean voyaging. The country has not yet forgotten the humiliation of seeing its proud battleship fleet escorted around the world by a motley crowd of British, Dutch and Italian colliers, because no American vessels were to be had. That was in time of peace, but the lack of such auxiliary ships and especially of loyal American officers and men in war might fatally cripple our fighting force and bring appalling disaster to the nation. A strong mercantile marine is one of the great essential elements of American "preparedness."

MERCHANT TONNAGE OF PRINCIPAL NATIONS AS RECORDED IN LLOYD'S REGISTER FOR 1895 AND ALSO FOR 1915.

	1895 Tons.	1915 Tons.
Great Britain	13,242,639	21,045,049
United States	2,164,753	*5,368,194
Austria	304,970	1,055,719
Denmark	356,714	820,181
Holland	446,861	1,496,455
France	1,094,752	2,319,438
Germany	1,886,812	5,459,296
Italy	778,941	1,668,296
Japan	301,101	1,708,386
Norway	1,659,012	2,504,722
Russia	487,681	1,053,818
Spain	554,238	898,823
Sweden	497,877	1,118,086

* Of this 2,970,284 tons were on the sea and the remainder on Northern lakes and rivers.

Outside of Europe and Japan, subsidies and mail payments have been reported for 1908 by the Bureau of Navigation as follows: Chile, $253,195; Mexico, $75,000; Egypt, $54,512; Brazil, $1,300,000; in all, $1,682,707, making, with the above, a total of $46,907,220.

(In the fiscal year 1914, the United States paid in subsidy to American steamers under contract the sum of $1,089,361.83, and the report of the Post Office Department states that "The net cost of the service performed was $55,155.51 less than it would have been if the steamers performing it had not been under contract

SUMMARY OF FOREIGN SUBSIDIES, MAIL PAY, BOUNTIES, ETC.

(From Report of the United States Commissioner of Navigation, 1909, pages 20-21.)

Great Britain and Colonies	$9,689,384
France	13,423,737
Japan	5,413,700
Italy	3,872,917
Spain	3,150,012
Austria-Hungary	2,984,530
Germany	2,301,029
Russia	1,878,328
Norway	1,102,143
Netherlands	880,011
Sweden	277,752
Denmark	145,000
Belgium	55,970
Portugal	50,000
Total	$45,224,513

and had conveyed the same mails and received pay on a weight basis.")

The figures above are the latest official enumeration by the United States of foreign steamship subsidies, bounties, etc. These subsidies and bounties have been somewhat increased since 1909 in most of the countries mentioned, together with a corresponding increase in their merchant shipping tonnage.

(Germany, in addition to subsidies, grants preferential rates on her State railroads on cargoes to be carried in German ships.)

Stammering, Its Own Explanation

By Ernest Tompkins, M.E.

THE stammerer looks at his watch and says: "Ten o'clock." You fail to understand and you glance at him inquiringly. He is dumb as quick as thought. Possibly his difficulty *is* thought: both are alike in quickness. Assume that thought causes stammering.

Observe the stammerer's contortions, as he compresses his lips, twists his mouth and does all the other distressful things that repel his auditors to his chagrin and disappointment.

What is most evident in those contortions? Effort.

What is the next most evident thing? Misdirection of the effort. He holds his mouth shut; but he should be opening it. He holds it open; but he should be closing it.

So far we have two elements, a thought and a misdirected effort. Do they belong together? Let us analyze the thought. What thought would occur to the stammerer when you wanted his words repeated? Answer it by another question, What thought is uppermost in the stammerer's mind when he is required to talk? Why, "I can't talk." That is the thought.

When a person is required to do what he fears he can not do, what does he do? He makes a desperate effort. It is safe to assume that the stammerer will make a desperate effort to talk. We see the effort and we see that it is misdirected. We also see that the thought of disability and the effort have a logical connection. And we know that frightened efforts are often misdirected.

Take for the theory that stammering is a misdirected effort prompted by a mistaken idea of disability. Understand that it is only a theory. The thought element was adopted on account of its quickness only; whereas the misdirected effort was obvious. The misdirected effort is the more credible element; but even its credibility is lessened by its combination with the less credible element, the thought. Consequently, the combination is merely an unproved theory.

If a key fits the lock we conclude we have the right key. If a theory meets the requirements we conclude we have the correct theory. But several keys might fit one lock. However, the theory has to meet so many different requirements that there is practically no chance for duplicate theories. It is an inflexible rule of science that the theory which best fills all the requirements must be accepted as a working theory until a better one is found, and if neither a better one nor the need of a better one is found the working theory must be accepted as the truth.

Let us see how the requirements are met by the theory that stammering is a misdirected effort prompted by a thought of disability.

Stammering does not begin until after speech acquisition: the number of beginnings is greatest then and it decreases with advance in age to practically zero in adult life. According to the theory, stammering could not occur until after speech acquisition, for a sense of ability would have to precede the thought of disability. Soon after speech acquisition the still insecure faculty could most readily be upset by misdirected efforts; but in adult life normal speech would be so firmly fixed that it could not readily be upset.

Stammering is frequently first observed after a convulsion. According to the theory, the physical weakness caused by the convulsion would make the child's speech halting, and would thereby instill an idea of disability which would prompt the misdirected effort. This explanation would hold for all cases arising from severe debility, such as sickness, injuries, fright, etc. Similarly, mimicry of stammering and the habit of repeating words—stuttering—would, when somewhat fixed, cause a thought of speech defect which would prompt the misdirected effort. In short, all verified causes of stammering justify the theory—a statement that cannot be made for any other theory that has ever been suggested.

Stammering is decreased to the extent of disappearance by solitude. According to the theory no fear of disability would arise, for it would matter not in solitude whether the stammerer talked or remained silent. Similarly, the little girl who stammers talks freely to her doll; the stammerer can readily repeat a remark which he knows you understand; and he can read or recite in concert.

Through all the long list of phenomena which characterize stammering, the theory will be found to fit. Consequently, this theory that stammering is a misdirected effort prompted by a thought of disability is probably the most reliable working theory that has ever been propounded for any disorder.

The application of the theory is that stammering is merely a habit—although a peculiar one—and may be stopped like any other habit merely by declining to indulge in it. The common schools are fostering the habit by requiring the child to stammer, and are spreading it as well, for stammering is highly contagious. When stammering is forbidden on school property the disorder will be unable to pass the schools and will be entirely wiped out after the adult stammerers seek cures or die off. Recovery may be hastened by increasing the usual amount of free talking; but this requires skill.

The Largest Plate Mill.—A mill for rolling steel plate that will be the largest in the world is now under construction for a Pennsylvania company. The rolls are to be 200 to 204 inches in length, and will produce a finished plate 16 feet wide. It is a four-high mill, the two working rolls of chilled iron being 34 inches in diameter, the other two being 50 inches.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, FEBRUARY 5, 1916.

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer;
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

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