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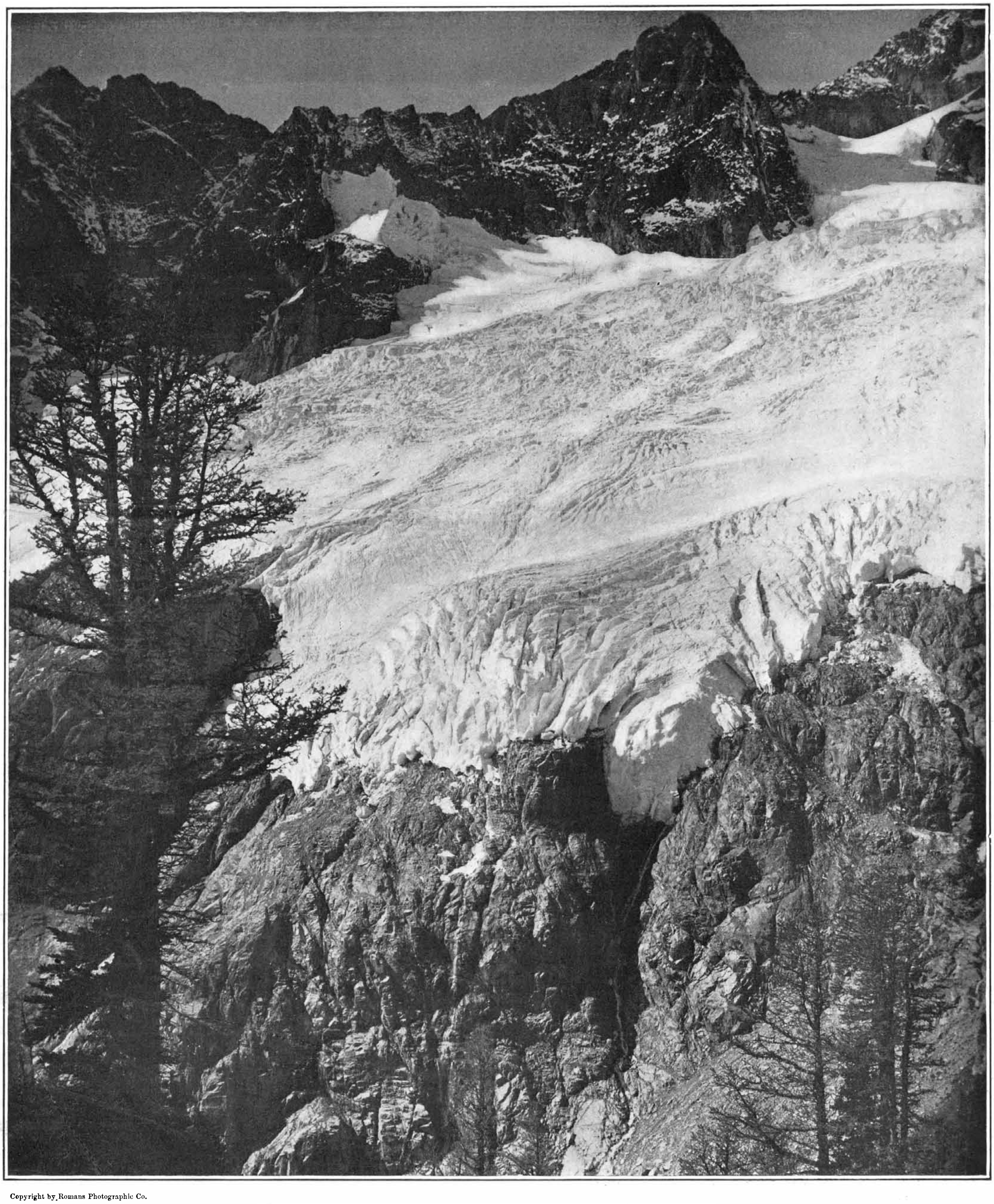




Isella Glacier of Washington. A remarkable example of a cascading glacier.

SOME AMERICAN GLACIERS.—[See page 280.]

# Economy in Study—II

## Educative Imagination

By Prof. George Van N. Dearborn, A.M., Harvard, MD., Ph.D., Columbia

In the first article we ran over some of the practical considerations of taking notes, both on the tablets of one's memory (observation) and on tablets of paper, which you will recognize as note-books. How we can practically further the use of these notes, both cerebral and manuscript, in the learning process, is our important next inquiry. This process in practice may be analyzed and understood, and improved in any given mind.

Imagination may not be easily defined to you except by suggesting what it is not: It is not falsehood and untruth, but a most essential form of mental truth, and educationally is of very great practical importance. Some of you are wondering how imagination as you think it can be important in learning at all. The reason for this is that a wrong meaning of the term imagination has crept into general untechnical use, namely, that imagination is delusion, a false idea, an error of thinking, the seeing of something that is not there; false perception—in other words, in general, error and falsehood rather than something which is real and in every way important. Imagination, on the other hand, is one of the most productive mental processes in the educational procedure. It is "the representative power" of the mind, but this, as we shall see, involves much, since in a broad sense it includes many of the active constructive operations of the mental life. Dean J. R. Angell, the eminent psychologist of Chicago University, emphasizes the two leading features of imagination when he writes that it "is to be viewed not only as the process whereby the ordinary practical affairs of life are guided, in so far as they require foresight, but also the medium through which most of the world's finer types of happiness are brought to pass." Surely a thing which at once guides our lives and gives us happiness is of much account; and in the learning procedure it is not of less account. Imagination may be denoted as the use of the mind backward or forward, turning the latter into the past or into the future, but not directly into the present. That is one of the most conspicuous aspects of the nature of imagination, but by no means all of them.

Memory is a form of imagination called *reproductive* imagination. Foresight in a broad sense is another form called the *constructive* imagination, which, however, we shall discuss in a way to include much more than this. Influence of the mind on the body is called *organic* imagination. Each form has notable practical concern in learning. Our present search is as to how this fact is so and as to the practical means of developing imagination, if not already ample and rich, in yourselves.

Let us now take up these three kinds of educative imagination, then, and see what we can suggest about them in the way of practical use in easy learning.

I. *Reproductive imagination*, memory or recall including both moral and mental. There is evidence that the nervous system retains every clear impression made on it, but how long we do not as yet know. A great many cases have occurred from time to time, which demonstrate that this in some way is the case. There are three general types of retention memory that have more or less to do with the reproductive imagination. Some of these "memories" are hereditary, inborn, and are represented in the spinal cord: the reflexes. The sneeze, the cough reflex, etc., are more or less unintentionally performed and controlled. Then there are some memories which are controlled further up in the brain, the *instincts* and *emotions*, having social as well as personal reference. It is important for educative purposes that these latter memories involve the previous kind as well. The third type of the reproductive imagination is located in the upper extremity of the nervous system, namely, in the cortex of the brain. These are the latest additions in the evolution of the brain. *Memories proper*, these are, and only a few of them are conscious at any one time. These last, like the preceding, should completely involve the other two.

The fundamental principle of *habit* is what determines the usefulness of these forms of memory for easy learning. Their respective power of recall depends on their relative influence on the more conscious parts of the brain. There is, then, one general learning principle, namely, that all these three kinds of memory should be given habitual yet conscious reference, as conscious as is voluntarily possible. Reduced from physiological to practical terms, this means that we come again to the skill that we spoke of last time; conscious acquaintance with all parts of the body that may properly come (without interference with function) under voluntary control. This is one of the physiologic bases of rapid and permanent acquirement. By this means every learning pathway is open for use in the acquirements of knowledge. Physical training here gets its highest sanction and usefulness.

The power of recall of what once has been remembered is one of the essential things for learning. The perfection of the memory record is beyond control, but this power of recall may be greatly developed. You must remember all the time that the brain acts more or less on the symbolic system, using a method of shorthand symbols which in some way were impressed in the brain processes; these are essentially *integrations.* Hence the need of *reviewing;* in order, namely, that these associations or integration complexes may be more intimately connected together, and with the rest of the mind. Recall is thus made easier and more useful for facts, and their relations are sorted out and labeled, oftentimes with a name, as with all "general ideas." By this means they are made far more available for use at will.

Another practical point for the use of the reproductive imagination is that *it should be impressed with a feeling of some sort.* It is the emotional tone of nearly everything of a mental nature which gives it its "push" and determines its useful activity. The exact kind of feeling for this purpose is not so important as is the fact that the memory should be associated with *some* sort of feeling tone. Feeling, and not the idea, is the mind's great energizer. Therefore, in general, one remembers best one's pleasant (or very unpleasant) experiences. That does not perhaps appear obvious at the first glance over your memories, but I think that in the long run it is distinctly true. It has recently been shown, in fact by actual experiment, that young school girls at least remember their pleasant experiences best. In other words, other things being equal, one should study chiefly and should remember those subjects which are pleasing to him. This is one of the reasons for the privilege of selecting subjects of study in school—the sanction of the elective system.

When the reproductive imagination (memory) seems wholly perfect to the individual the experience is called an hallucination. Thus when one has an hallucination he perceives something which is not really there at all. This happens only under conditions of mental overstrain, or of derangement of some sort. So far as the perfection of recall is concerned it is quite impossible for a really perfect reproduction of the original impression. The moral of this discussion of the imperfection of the imagination is that the memory is never exact. Recall is never normally exact, and the student must act on this principle in all ways.

But none the less, the reproductive imagination is often of very great service in learning, both in the recall of words seen and heard, etc.; continually, but in picturing to one's self for use the conditions of hidden or absent structures. We have already in our introductory article noted how indispensable the visual imagination, in both its reproductive and its constructive aspects, is in anatomy, physiology, pathology, medical diagnosis, and so on. The same is almost equally true in many other sciences—in fact, in most branches of learning. The difference, for example, in the liking or dislike of geometry by students depends largely on their relative power of *visualizing* the spatial problems involved. One, then, *should develop to its limit this power of seeing things in the mind's eye*—and of hearing them, and feeling them and smelling them and tasting them. Thus the material world is, for educative purposes, extended in far wider mental relationships than otherwise.

II. The second form of imagination that we will discuss is *constructive imagination.* This is by far the most important of the three for educational purposes. The reason that recall of one's memory is never exact is that the mind is an active process, always *doing* something. The neurons are alive with energy and always develop their mental contents. Thus all imagination, educationally speaking, is more or less constructive. You have heard it said that one learns to swim out of water in the winter time, or to play tennis; one sometimes learns to love a person better during his absence, which "makes the heart grow fonder." These are all processes of constructive imagination, and in the last case, when you get back to the beloved person you sometimes realize the constructive difference. This all, of course, is a subconscious process; but in the human mind imagination has more power than the relatively passive subconscious development.

You have the ability to *force* the constructive imagination, just as one has the power to work out a line of thought, for example in writing a composition, an essay, a thesis, or a book. All real education is developed thus, namely, by the unrolling of intelligence out of materials obtained everywhere and all the time, mostly subconsciously. One may have much knowledge and even learning, but not *education* without this constructive process of imagination. The more conscious this construction, the better and more useful for the student. When conscious this is called thought (technically "ratiocination"), which we shall describe and apply later.

It is interesting to consider a little more in detail the constructive imagination. It is really a very remarkable process which we may try to analyze. There is such a large individual difference in people that it is scarcely possible to find two people who will agree to the same statements as to the facts. But take for example, a musical theme, or a simple melody commonly called a tune; heard once, in my own case, this is not recalled, save in the smallest bits, a bit here or there. But heard twice or more: then three or four wholly silent days elapse, with total submergence, that is, nothing at all is heard from it. Then, curiously enough, it begins to become conscious, now and then a strain here or there in the melody. If then I hum or play a few strains the missing parts, more or less complete, soon appear, but gradually and in fragments, especially if I whistle or play these fragments on some instrument. *Performance* of some kind is generally essential to recall. You have to push the imagination association. The process is repetition, even to automaticity, even to triteness. If the new tune is attractive there is a distinct tendency to hum it and sing it until it gets more than tiresome. It has now obviously by this time become a real part of one's mind. It then, perhaps more or less actively, sinks into the subconscious mind, having been repeated until it is positively unpleasant. When a tune has become so familiar on a basis of pleasure, it tends to thus repeat itself even to dismissal.

This may be employed as a useful type of conscious imagination, and we may suggest more details from this illustration for the process of learning. Let us analyze a little more fully what has taken place in this common experience of learning (by the constructive imagination) an ordinary sequence of musical tones. We find six more or less obvious, but yet arbitrarily chosen, elements in this process. First there is an impression on the mind, which is subconscious in the mind, or in the nervous system, as you care to state it. Secondly, we find a process of unconscious integration, in which period (several days in the case I used as an illustration) there is no awareness whatever of what is going on. Third, there is a fragmentary flotation into consciousness, and these fragments are made more conspicuous by use and by repetition. Fourth, there is a process of conscious integration by effort, and this is by far more effective if it be helped by motor performance, such as humming, singing, playing it on some instrument or whistling. Fifth, there is a stage of conscious familiarity, or even of over-familiarity. And sixth, there is a real mental submersion, the melody being there then as real knowledge. Now I take it that all matters of knowledge, all acquirement occurs more or less in the same way, whether the precise learning be the Constitution of the United States of America or the irregular French verbs, the rule for finding the cube-root, the provoking rules of Latin grammar, a set of propositions in geometry, the physiology of the regulation of the body-heat, the geologic periods, or what not. I take it that the process is always in some degree the same as in the impression and recollection of a new melody. Let us work it out a little better practically.

1. The material to be learned is read through once or twice, but, being relatively difficult, is not consciously learned. The practical point here, if any is at hand, is the importance of *concentrated attention* on the more difficult and arbitrary material in a subject of study in order to impress the brain all the more vigorously. Retention would often be aided, too, as has been said, by doing this study with some emotional tone, preferably one of determination or enthusiasm; but even anger!

2. The mind, finding the material and its acquisition expedient, works it over, not only within itself, but more or less also with the former contents of the mind. The practical moral of this interval is obvious: *the value of review*, which reinforces the impression on the brain. Another moral is *peace of mind and absence of worry*—implying implicit trust in the subconscious fusion process of the mind.

3. Fragments here and there float into consciousness, so that one is reminded that the mind is working on them, and thus is kept at it.

4. At the next attempt at learning (whether it be a few hours away, or a few days) effort is used, what we call conscious study, and we find integration easier than before. *Going over the same material* to be learned, after a few days, deliberately and carefully once or twice, *lends one confidence in one's mind* by showing that processes are helping which are unknown to the student at the time.

5. The stint is then learned, and you are conscious of the fact. Here work, and especially motor, expression —work on the material, is very productive, making it thus thoroughly familiar by the instinctive pleasure of creation, of learning, and on the principle of imitation or habituation. The importance of working over the material in some motor way (usually writing it or talking it to some one, if it be only one's-self) comes out here. Also the importance of repetition.

6. The material is then "forgotten," so-called forgotten, but in reality is really learned and is in the mind in the best possible form for use as required.

Such are some of the practical hints toward easy learning that may be suggested, even in a process as abstract as the constructive imagination.

This is the standard *modus operandi* of the learning mind, at least on all series of difficult facts and principles. The less arbitrary and more interesting the material, the easier this mental process is, and the simpler, although the same in principle. This is the process sometimes known as the association of ideas. Try to analyze it a little better in the light of the actual association of the tune.

A practical point may be noted at this point: If the desired thought or relation, or whatever be the kind of association process desired, cannot be produced by a few minutes of really concentrated effort, it is not scientific to try further at that time without a break in the mental effort. Rather should one await a brain refreshed by a little rest and helped by the subconscious integrative actions that are pretty sure to be set going by the conscious effort already made. When the problem is taken up consciously again, later in the hour or the day or the week, the chance of success, other things equal, will be much improved, and that without risk of uneconomical fatigue. Moreover, there is such a thing as absolute block of the will in this constructive learning—else of course there would not be the empirical definite limitation of ingenuity and invention. Well do I recall an instance in which William James, master in constructive thought, showed just this phenomenon before a small class in philosophy—he said, after a minute or two of strenuous effort, that he had "tried his best repeatedly to work out that particular thought, but that he *could* not advance his construction" beyond a certain relatively incomplete stage.

Imagination of the thinking kind tends to make ideas more "massive," and so more educative. Massiveness makes them easier to realize in their actual meaning, in this case more imaginable.

The next topic in regard to constructive imagination is the matter of complexes of mental units. Knowledge is in the mind in some way in the form of mental integrations. Morton Prince termed these "dormant ideas," units in some sense or other not yet clear to physiology. These mental units have dynamic relations which they and the nerve energy have in common, so that "ideas," especially when colored by a definite feeling tone, have an inherent impulse to interaction.

An effort should be made, then, by the student in all ways to make these complexes, 1, as *numerous;* 2, as *complex;* 3, as *active;* 4, as *permanent;* 5, as generally *useful* as possible. The process of so making them is *effort*, and is at once imagination, thought, association and remembering combined. Now one can make these complexes of the mind, these dormant ideas or units of mental process, more, 1, *numerous* by reading, talking, by taking notes, by observation, by thinking; in short by all the common modes of acquiring new concepts or ideas. 2. One can make them more complex by practically the same means. 3. One can make them more *active* (*a*) by including in the complex an emotion or a feeling, one of the ninety or so of which I have recently published a list and brief discussion. These constructive complexes in the mind may be made more active also by (*b*) developing interest, instinctive or personal, and (*c*) by association with material which already has interest or emotional tone for you. William James has emphasized this essential fact in his valuable "Talks With Teachers." He says that "any object not interesting in itself may become interesting through becoming associated with an object in which an interest already exists." Also by Pavlov and more recently by Watson at Johns Hopkins (as discussed in the previous article) it was found that there is no assignable limit to the arbitrariness of the association that may be "artificially" made in the nervous system. Nerve surgery suggests precisely the same thing, for, as has been often shown in practice, a cut sensory nerve may be sutured even to a motor nerve stump, and the sensory function return in all its essential completeness. There seems to be no end to the power of association possible in the nervous system. 4. *Permanency* of the mental units or complexes may be reached best by way of (*a*) emotional tone; (*b*) by the richness of the recorded relationships; (*c*) by the intensity of the personal attention when the perception first takes place; and (*d*) by the frequency of review, among other means. 5. The *utility* of the mental complexes or units is reached automatically by the mere avoidance of thoughts, etc., of the scholastic type, problems and theories which have no deeper reality or basis in fact than the chance relationships of pure ideas, verbal quibbles. One should for the most part think of and discuss real problems with some really human applications.

Originality, ingenuity, skill are terms for a productive and efficient constructive imagination. One who lacks these is not educated. Skill, as we saw in the previous article, is a kind of potential imagination. We may suggest a working rule for becoming able in this line of constructive imagination, may one be pardoned, in almost slang terms: *Get posted; get energetic; get interested; get busy; and try.* And keep on trying. Trying in any intelligent mind develops its own personal method, and one cannot be told how to improve these methods in the subconscious mind. Habit makes it easier and easier to remember, and more and more productive as well as easier. Constructing and constructive imagination becomes after a while in itself (something which one always has ready in hand) a vast pleasure and delight. Not only in ideation, but in feeling and willing, is the mental activity worth cultivation for its own sake—like virtue and beauty its own reward.

Feeling imagination lends emotional tone to the mental process and so gives it delight, or at least satisfaction, as well as power. This may be seen readily in poetry and in music. We have discussed elsewhere the sthen euphoric index (which is not really so bad as it sounds). It means that you expend more energy in doing things that you enjoy doing than in those that are unpleasant to you. This is of the utmost importance, of course, practically.

Imagination is at once a most practicable and a most valuable educative process. Invention and scientific research would be unproductive without it. One of the greatest pathologists of recent times, Paul Ehrlich, discoverer of salvarsan, spoke of his chemical imagination as his "greatest asset." Here some of my hearers are suggesting to themselves that the use of the imagination leads to what has been once and forever abandoned out of science and education as the deductive method. But the use of the constructive imagination is not "deduction," not a fitting of science to belief or to dogma or to mere opinion, but is rather an elaborate case of the method of trial and error. In using one's imagination scientifically, constructing a theory, one first sees if it *fits*. If not, he must be willing to throw it aside frankly and promptly; the only danger lies in obstinacy. Examples are innumerable of the great usefulness of this common method of trial and error. The indispensable employment of imagination is shown in the planning of the Atlantic cable, the telegraph, the wireless, the telephone, the electric light, submarines. These and such could not have come into existence without a preliminary use of some one's creative imagination. Theories, hypotheses, philosophies, are all impossible without it. Imagination is at once more useful and more used than is known in education. No knowledge can be made one's very own without this creative process, often called "assimilation" to the contents of one's mind. Summarizing, reviewing, and abstracting is a practical and mechanical method of using the constructive imagination. Better still is the process of using one's memory to the best advantage, thought, thinking things over that you have just learned; there can be no true education without this process, for it means self-reliance, independence. Thought over a study topic tends, by association, to go beyond the original limits of the assignment as learned, and this is imagination. Thus it becomes the basis of initiative, of ingenuity, and of originality.

The *creation of diagrams* and illustrations is using the imagination to a very great advantage.

The constructive imagination may be aided and consciously and deliberately developed by the proper means. In childhood, by the reading or hearing of fairy stories, and later on by the reading of books like "The Fairy Land of Science," Thomson's "Wonders of Life," histories of discoveries, Sir Oliver Lodge's presidential address on continuity, novels like those of Jules Verne or H. G. Wells; talking with fanciful and imaginative persons, and often by an active process of deliberate revery.

Another mode by which the creative imagination may be developed is the enlargement of one's vocabulary, one's list of words, and the habitual use of these idea handles in writing. New terms lead to new associations. In general, as we shall see, the dictionary is not used nearly as much as it should be for easy learning.

III. The third kind of imagination which we mentioned was the *organic imagination.* This may be termed the influence of the mind over the body, suggestion, and this is a very familiar word to all of you nowadays. This is a very strong and important process in education. Ordinarily one's interests are unrealized and one's capabilities unknown. Millions of indigent and neglected children are thus hadicapped. The playgrounds, camps, etc., develop this knowledge. The basis of organic imagination is strictly physiologic process, and I state each year with more and more emphasis, the result of observation direct and otherwise, *that there is no assignable limit to the voluntary control of the body.* This matter may be extended to the intellectual subjects of education as well as to bodily education proper.

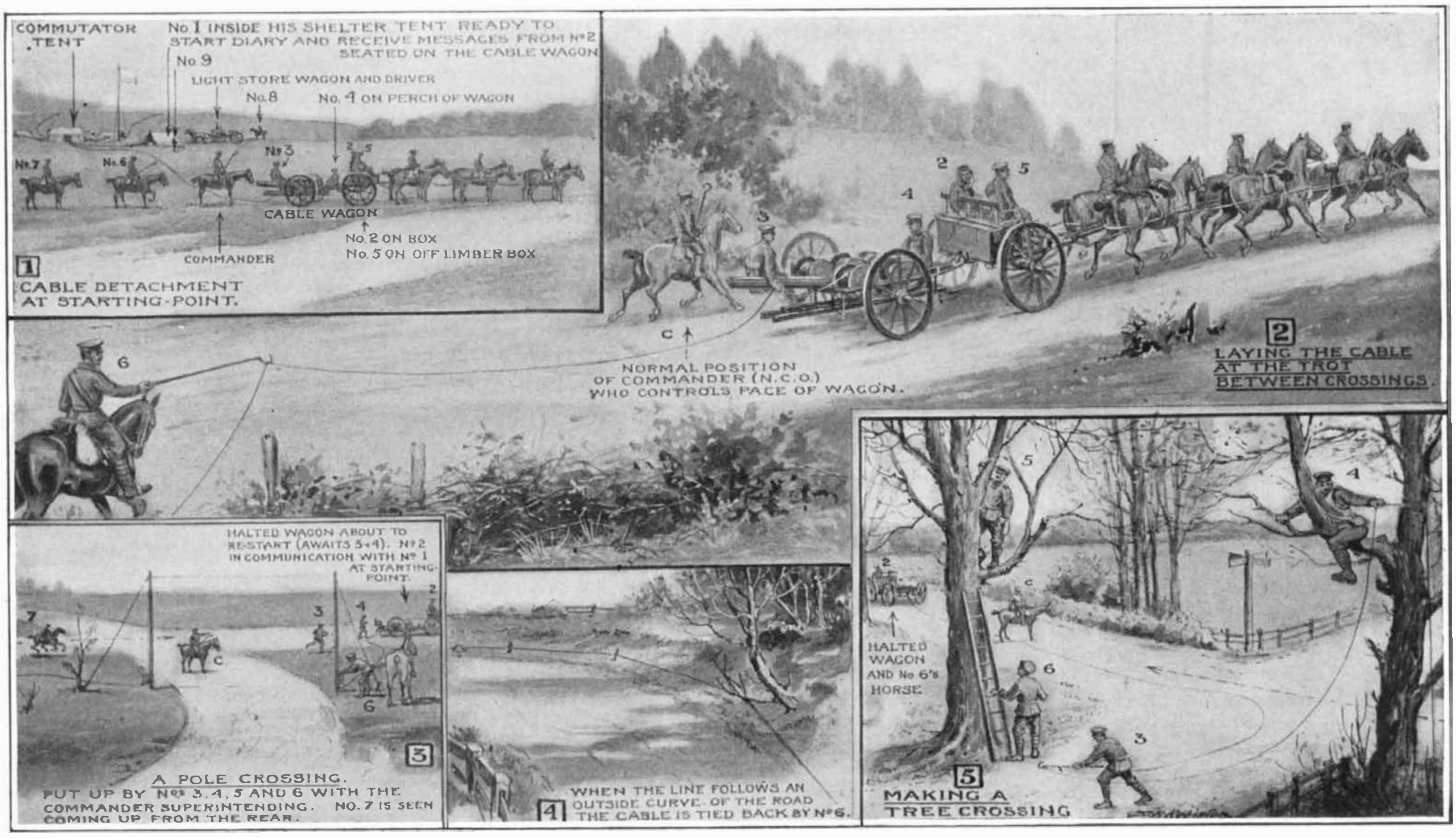
Ideas that are inherently meaningful in human reason; or that are massive, full of detail (for example, laboratory work and direct observation); or that are especially striking because of contrast effects or from other conditions, exert the most suggestive influence, and are thus the richest educationally and stimulate the imagination most. None the less the use of the organic imagination in general is perhaps more hygienic and ethical than narrowly educative. But this, too, is education, how to be *well* and how to be *happy.* This invaluable part of learning, the organic imagination, however valuable, we must ignore in these discussions. But all the Why Worrybooks, and the New Thought, and Christian Science (its irrationalism aside), all the mind-cures and some of the really scientific psycho-therapeutics, are applications of the organizing of the organic imagination. This is a suggestion which is of much value to easy learning.

### Business in Engineering

In an address to the Junior Institution of Engineers, Mr. F. G. Hatch emphasized the importance of the commercial side of engineering from several points of view.

The young engineer too often thinks that all engineering matters should be regarded as having only technical interest, and that commercial considerations are beneath the notice of the engineer. But every engineering undertaking and appliance has to stand a test, not only of its scientific interest or accomplishment, but finally of its practical and commercial value. The ability to judge of this value and turn it to account is an important part of the business of engineering, and this aspect of this work is not sufficiently born in mind, especially by younger members of the profession, or business. It is rarely mentioned by their early teachers and masters, or in the classes of colleges or technical schools. It is no wonder that in view of the fact that engineering students receive no regular business training, engineers as a whole are poor business men. It seems easier for a business man to get a sufficient grasp of the general principles of engineering to enable him to control a works than it is for the engineer to get into business ways when time and advancement make it necessary for him to do so.

There is undoubtedly among all technical men a feeling of contempt for financial results. They feel their existence and position is justified when whatever machine they are turning out works well, looks well and wears well. If it does not sell well or bring the desired financial results, this side of the question is dismissed without further thought than that it is a pity; but from their (the technical) point of view, virtue is its own reward, and in any case it is "up to" the commercial side to look after this side of the business. They, as engineers, cannot soil their hands or occupy their minds with any sordid commercial considerations. The commercial side, finding that they, and they alone, have to bear all the burdens of financial success, set themselves to obtain the desired results with very scant sympathy for technical considerations. Thus it is brought about that the technical men do not have much influence in controlling the policy and affairs of their firm, because too often they have failed to get those results which are the only final interest of directors and shareholders.—*From an address to the Junior Institute of Engineers (England) by F. G. Hatch.*




Courtesy of the *Illustrated War News*.

**Sketches illustrating the operations of telegraph engineers at the front.**

# Field Cables*

## Keeping Up Communication Between Divisions of An Army.

A CABLE detachment consists of a non-commissioned officer commanding the unit; three office telegraphists, dismounted, numbered 1, 2, and 9; three sappers, numbered 3, 4, and 5; and three linemen, numbered 6, 7, and 8 (Fig. 1). Each man carries a knife, a pair of pliers, and a length of spun yarn or coarse rope; while the commanding officer has also a whistle and a crook-stick; No. 4, a whistle; No. 6, 100 yards of cable, two pieces of tubing, a mattock, a whistle, a crook-stick, and two pegs; Nos. 7 and 8 carry the same equipment as No. 6, except the whistle. The cable itself is coiled on drums carried on a cable-wagon drawn by four or six horses (Figs. 1 and 2). The operation of laying the cable is carried out as follows: No. 1 takes his office equipment from the wagon-box and connects his transmitting and receiving instrument with a short length of cable leading to the commutator or local "exchange" instrument. He also connects another terminal with an "earth" wire. The end of the cable on the wagon having been also connected with the commutator, telegraphic or telephonic connection is now established between No. 1 at the starting point, or base office (Fig. 1), and No. 2 on the wagon; and this communication is kept up during the whole operation of laying, test signals being exchanged every two minutes. If No. 1 receives no signal over a space of five minutes he assumes a "fault," and sends No. 8, who remains at the base office for this purpose, along the line to remedy it. After No. 2 has assisted No. 1 to remove his equipment from the wagon, he takes his seat on the box of the latter, and, putting on his head-receiver, exchanges calls with No. 1. As soon as satisfactory communication is established between them, the work of laying proceeds, No. 2 remaining on the wagon-box to receive and transmit messages as required. No. 3 pays out the cable from the drum (Fig. 2) as the wagon moves along. No. 6 rides behind, and by means of a crook-stick guides the cable to the position where it is to remain. A light wagon attached to the unit to carry provisions and stores remains at the base office in charge of No. 9 (Fig. 1).

When all the cable has run off a drum, the latter is thrown to the ground, and the end of the cable is passed through it to prevent its removal. The speed of the wagon varies according to circumstances. Under good conditions, three miles can be laid in one hour; but half of this is considered good work if done in the dark.

When the resting-place of the cable lies on the outside of a curve it is necessary to tie it back (Fig. 4) at frequent intervals, unless suitable posts or stakes are available over which it can be thrown. When this tying back (Fig. 7) has to be done immediately, No. 6 undertakes it, and the commander himself takes his duty at the rear of the wagon until he can rejoin. No. 4 sits on the wagon facing backward, and closely watches the cable running out (Fig. 2). If a hitch occurs he instantly stops the wagon by blowing his whistle. This man also controls the brakes on the cable-drum. No. 6, as before, rides about ten yards behind the wagon along the line on which the cable is to lie, and guides it to its resting-place. No. 7 rides far enough in the rear to note the condition of the cable after the strain is off it, and has the final responsibility as to its efficient situation when laid (see Fig. 3—No. 7 catching up at crossing).

A road may be crossed by a "pole crossing," to form which two poles are erected, one on each side of the road, the lines being stretched across their tops, the poles themselves being supported by guy-ropes (Fig. 3).

Where trees are available, these take the place of the poles, and a "tree-crossing" is formed (Fig. 5). In order to lead the line over a railway the cable is cut and passed beneath the metals. To make a joint after cutting, or to attach an additional length of cable, a portion of the insulation near the end of each length is removed (*A*, Fig 6), the two exposed wires tied together by a reef knot (*B*, Fig. 6), and the joint covered by a rubber sleeve previously passed over the end of one of the lengths of cable, and slipped back into position after the knot is tied (*C*, Fig. 6). Illustration No. 2 appeared in a previous issue of this paper. It was necessary to repeat it in order to explain the other diagrams here given for the first time.

* *The Illustrated War News.*

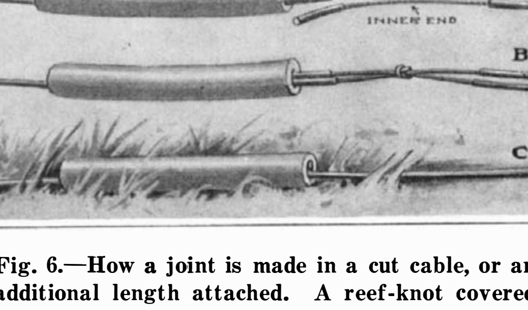



**Fig. 6.—How a joint is made in a cut cable, or an additional length attached. A reef-knot covered with rubber tubing.**

*A*, the outer end of the cable on each drum is always kept ready for joining, as above. Each inner end is similarly prepared, but without rubber tubing. *B*, the ends are tied in a reef-knot. *C*, five or six inches of rubber tubing are drawn over the tied ends to insulate the joint.

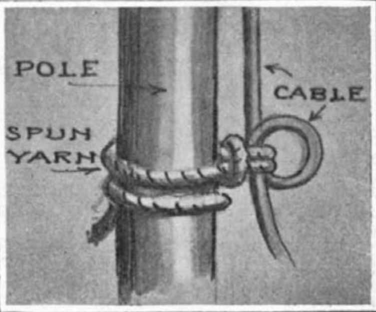



**Fig. 7.—How a cable is tied back to a pole, as in Fig. 3 in above illustration.**

This diagram shows how the cable is looped and made secure with a piece of spun-yarn to the foot of a pole (see Lineman No. 6 in Fig. 3), a tree-branch, or a projection on a building when passing through a village.

### Pneumatic Massage

A VERY effective as well as simple device for obtaining massage of limbs which have been rendered inactive by the ankylosis due to a long inaction in case of maladies, is brought out by Dr. Bergonie, a well-known French scientist. The wounded are subject to this drawback, owing to adherent scars which come from wounds, or by long repose due to treatment of fractures, in which cases the limbs become deadened from lack of movement. He treats the member by a mechanical massage upon the pneumatic principle, by using a large box one of whose sides is made up of an elastic membrane (Marey device). The limb is held in such a way that the membrane comes in contact with it, then when an air pressure is exerted on the box, by the air pump, the membrane swells out and presses on the patient's arm. If the pressure is supplied in the form of pulsations of air, a veritable massage is obtained in this way, and it is very exact, for the pressure can be regulated from high to low by a simple adjustment, though all degrees. Again, the frequency of the pulsation can be regulated within a good range, and can reach 120 pulsations per minute. The present method has a great advantage of needing only a very simple apparatus, and at the same time is powerful and effective.

## Leaf Photography

In green leaves exposed to sunlight a very remarkable and important process takes place—the assimilation of carbon dioxide from the air. Starch and other organic compounds are produced from carbon dioxide and water, with evolution of oxygen, in the grains of chlorophyl, the green coloring matter of leaves. Prof. Hans Molisch, celebrated for his researches on luminous bacteria and fungi, has produced photographs on living leaves by combining this natural process with the well-known reaction between starch and iodine, which unite to form a blue compound. Dr. Molisch has described his method in *Die Umschau*, from which the following abstract is taken:

The starch test is conducted in the following manner: The freshly cut leaf is steeped in boiling water for half a minute and is then immersed in warm 80 per cent alcohol, which extracts the chlorophyl. After a little time the leaf, now white, is immersed in dilute tincture of iodine, where it assumes a tint varying from pale violet to blue-black, according to the quantity of starch present.

If the leaf, before its removal from the plant, has been exposed to the sun all day, with part of its surface covered by black paper, the part so covered remains white, showing that starch is formed only where the sun's rays strike the leaf. If a stencil plate is substituted for the black paper, the letters appear dark blue on the white leaf. These experiments are old and well known. Long ago Dr. Molisch substituted a newspaper headline for the stencil, and thus produced white letters on a dark blue ground (Fig. 1). The sharpness of the letters suggested the possibility of making photographs on leaves. The results of the first attempts were not encouraging, but the defects of the process were gradually eliminated until complete success was attained.

The leaves of the Indian cress (*Tropaeolum majus*), a familiar garden plant, are especially well suited for these experiments. Very good results are obtained also with leaves of the scarlet runner (*Phaseolus multiflorus*). The essential requirements are that the leaf shall be very smooth, thin, hairless and sensitive to the starch test.

A negative with strong contrasts is fastened securely in contact with a growing leaf, free from starch, and exposed to full sunshine for several hours. The leaf is then cut off and treated with alcohol and iodine in the manner already described. The result is a positive photograph, often of surprising sharpness (Figs. 2, 3, 4).

Probably a negative photograph of a brightly illuminated object could be made by substituting the growing leaf for the sensitive plate in a camera, but this experiment has not been tried.

It is essential that the leaf shall be quite free from starch in the first place. Usually the starch formed during the day is entirely converted into sugar during the night. If this is not the case, the leaf must be prepared by covering it with black paper for a day or two.

*A priori*, the probability of obtaining sharp photographs by this process seems small because of the disturbing effects of the leaf ribs, the various constituents of the leaf, and the dispersion of light by the cells and the air spaces between them. Despite these obstacles, portraits of persons can be recognized at a glance.

These leaf photographs possess great scientific interest, for they show that the production of starch is localized sharply by the incidence of the solar rays and is proportional to the intensity and duration of the illumination. This is proved by the sharp contrasts and fine gradations of tone exhibited by the photographs.

Fig. 1.


Fig. 2.


Fig. 3.

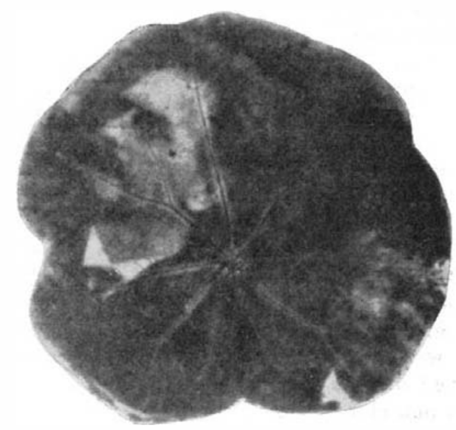


Fig. 4.

## Electric Cooking Ranges in Hospitals

The accompanying illustration shows the use of the modern electric range in an up-to-date hospital. Such an electric range is in use at the Southern Indiana Hospital for the Insane at Evansville, and a still larger electric cooking installation was recently provided at the Montana State Hospital for the Insane at Warm Springs, Mont.

This large range was designed to cook for fifteen hundred hospital patients and employees, following an investigation of the practicability of electric cooking. This is said to be one of the largest electric ranges in the world, and is utilized in connection with an unusually efficient system of food handling and serving between the hospital kitchen and the dining rooms. This range has a connected load of 69 kilowatts, and is built in four similar sections, each 7½ feet long and 2 feet 9 inches wide. It is installed with sections back to back, occupying a floor space 5½ by 15 feet, enabling the cooking staff to work on both sides.

In the arrangement of equipment, the range occupies the center of the kitchen under a large skylight, the ceiling being 23 feet high, and the kitchen is finished with tile floor and enamel-finished woodwork. A steam cooking apparatus is planned for one side of the room, in front of several large windows. The layout was made on the assumption that the principal part of the service would be from the corner of the room at the head of an incline leading to the dining room. Service wagons with rubber tires pass around the kitchen anti-clockwise, and discharge the soiled dishes at a washing section near the dish closet, taking on clean dishes and linen, and then passing around the cook's table and serving table, where they are loaded with food on their way to the dining room.

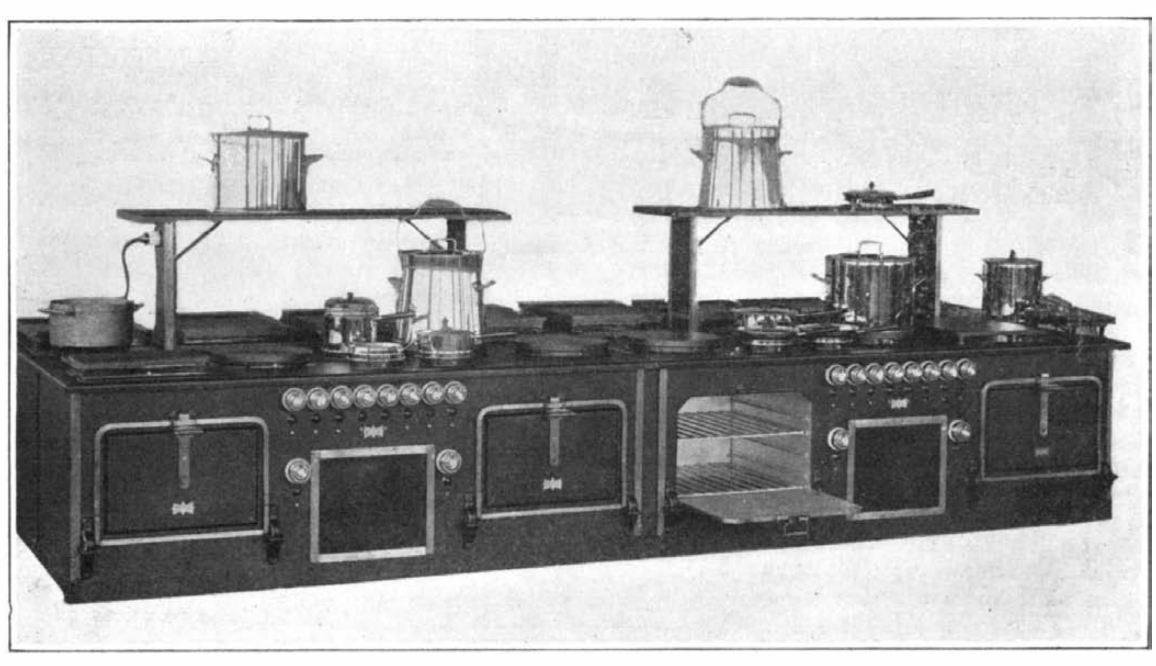
At present the hospital has 1,,000 patients, with 100 on the staff, and other workers requiring a total of 1,200 persons daily, three meals each, with a future requirement of 1,500 persons' meals daily. The range is similar to one installed at the Southern Indiana Hospital for the Insane, which provides for 1,000 persons, but the Montana range has eight ovens instead of six and a proportionate increase in the top equipment. There are two ovens in each of the four sections, each oven having sufficient capacity to roast 24 chickens or 80 pounds of beef at once. Each section is a complete unit in itself.

If the sections were placed in a single row the range would be 30 feet in length. The range is of steel with polished trimmings, and is said to be superior in workmanship and durability to coal and gas ranges. The top equipment comprises the following units, each controlled by a separate switch with ruby pilot light and three adjustable heats. It has seven 18-inch by 24-inch hotel griddles or hot plates and one 12-inch by 18-inch corrugated surface broiler, also one 12-inch frying kettle for deep fat and one 6-slice hotel type bread toaster together with five 15-inch, two 10-inch, and five 8-inch round hot plates.

In order to facilitate the work of the range, special copper and nickel plated cooking utensils are utilized with the range, including two 9-gallon kettles to fit the 15-inch hot plates and two 5-gallon double boilers to fit the 15-inch hot plates, also one 3½-gallon kettle and one saucepan, to fit the 10-inch hot plates, together with one 4-quart double boiler, one 5-pint saucepan and five frying pans to fit the 8-inch hot plates. It is maintained that these utensils are more efficient for electric range service than ordinary equipment. The outer vessels of the 5-gallon double boilers are of 7 gallons capacity each, and the inner vessels can be used separately as kettles. The outer vessel of the 4-quart double boiler is of 7 quarts capacity and can be used separately as a sauce-pan. The frying griddles are equipped with rims ½ inch deep and are to be used in broiling and in all classes of work usually done in a frying pan. The griddles and disk heaters are largely interchangeable in use and are designed chiefly for boiling outside that performed by the steam cooking apparatus in service at the hospital. The heating units are of the enamel type and the controlling switches are conveniently mounted on the front of the range at a height providing for minimum labor in handling.

It is clear that no smoke flue is required and the labor of installation consists merely in placing the range in position after assembling the sections and connecting the leads from beneath the kitchen floor to binding posts provided on the inside of the body of the range and accessible through removable panels between the ovens. The maximum demand is 46 kilowatts, and on the basis of 0.25 kilowatt-hour per person per day, the energy consumption is 250 kilowatt-hours per day, or 7,500 per month, making the cost of electricity on a 2-cent rate $150 per month. This is offset against the cost of coal, cost of handling coal and ashes, and additional attendance required for handling a coal outfit.

It is claimed that there is also a decided saving in food due to superior cooking as compared with coal or gas ranges, avoiding waste due to over and under cooking and excessive shrinkage, which in many installations amounts to more than the cost of fuel. The space required by the electric range is less than needed by either a coal or a gas range of equal capacity and electric cooking is ideal from every point of view.


Large electric cooking range for use in hospitals.

**A Test for Photographic Papers.**—A simple test of the permanency of photographic papers is to cut a finished print in two, and exposing one half for a few hours in a jar to the fumes of ammonium sulphide.

# Lutes and Cements*

## Materials of Value to the Chemist, Physicist and Experimenter

By S. S. Sadtler

I USE the words *lutes* and *cements* together for two reasons. First, because they have different meanings, the former referring to temporary applications and the latter to more permanent uses. Second, the use of these words conjointly shows to a casual reader that the subject of this paper is not solely with reference to Portland cement.

Quite a few years ago I read several papers on the present subject. In these papers I classified the formulas according to composition in one instance and according to intended use in another. These papers were noticed by a number of people who communicated with me, particularly engineers.

It is very difficult to give proper credit for what one finds in the literature, as some of these formulas are like humorous stories that are rarely traceable to a source. In looking up this subject for the present occasion I noticed some eight or ten attractive formulas in a well-known handbook of industrial chemistry. These were credited to a periodical which I soon found quoted in one of my papers, and I was not the originator of more than a few of them. Thus, things are passed on. The value of the formulas was diminished, however, by reason of the space allotted and the changes made.

I will classify the formulas now as I did before the Engineers' Club of Philadelphia, by the use of the following subdivisions. Very few of the formulas given herewith have not been tried by me. The only instances are where the authority was excellent and adequate trial was not practicable for some reason.

*Waterproofing.*—Of the chief bituminous substances available we have pitches, asphalts, gilsonite and blown petroleum residues, mixtures of these substances and mixtures of the same with inert material.

(*a*) Of the asphalts I prefer a substance like refined Bermudez, as it is nearly pure bitumen and forms homogeneous solutions with suitable solvents. A minor percentage of boiled linseed oil or blown petroleum oil is useful sometimes for tempering or fluxing. For solvents heavy naphtha is generally used. It does not dissolve all the asphalt, such as the so-called asphaltene portion, but it thins out the asphalt well enough. Coal-tar naphtha is better but more costly. As voids are very apt to form in a painted asphalt coating, some form of filler is generally employed, either by coating paper so that it becomes more or less impregnated or by the addition of a filler, such as silex, infusorial earth, etc. The natural mineral filler of Trinidad asphalt may serve the purpose of such filler.

(*b*) For a soft, water-tight coating in cement work, blown asphalt and infusorial earth, thinned with a solvent, such as heavy naphtha, is employed.

(*c*) The use of blown asphalts with natural asphalts and gilsonite is in some cases desirable, as these products are ideal fluxes for hard asphalts and tend to prevent brittleness or separation of the films when the solvent evaporates. The harder or higher melting point grades of these blown residuums are capable of making good cements alone or with filler, but are rather hard to dissolve. Such artificial asphalts have melting points as high as 150 deg. Cent., while the softer ones that are probably best for fluxing have melting points about 80 deg. Cent.

(*d*) Lutes of boiled linseed oil, thickened with clay, asbestos, red or white lead, etc., are waterproof, if thick enough from the filler added.

(*e*) Flaxseed meal made into a stiff paste with water is useful as a lute for steam connection and is easily applied.

Portland cement only serves as a waterproof cement when given time for the preliminary setting to take place. It is not generally impervious to water, and because of its colloidal character while setting it seems hard to realize that it could ever act other than as a water pervious diaphragm. But when fully or reasonably well set and dry the colloid character no longer exists and does not return to these particles that have taken part in the setting from hydration.

For all practical purposes the use of trade preparations, such as those containing metallic soaps or oil emulsions, serves to render concrete approximately impervious, but I will refer to a few points I have noticed in making or using lutes and cements.

(*f*) For making small experimental electrolytic cells, etc., for demonstration purposes, I have found it desirable to use white iron-free Portland cement and white plasterers' sand that had been sieved. If a one-to-two mixture is made with the prescribed quantity of an approved waterproofing substance, such as the product of the Newberry patent, and care is taken to work out voids and the article in the *green* is kept moist, a very nice waterproof container can be made. It will also stand dilute acids or alkalies, but not the two alternately. For large articles wire-mesh reinforcement is often desirable, and if the vessel is used for dilute acids this might well be made of a mesh of Monel metals, etc.

(*g*) In the literature on this subject, if it can be dignified by that appellation, one finds frequent reference to making lutes with Portland cement and silicate of soda. Some of these may work and others will not, and I approach them with caution. A little silicate of soda in the water will help toward a quick initial set, for instance, for under-water work. Water containing 4 to 20 per cent of silicate of soda by volume causes a preliminary set in 2 hours that prevents washing away by water. It injuriously affects the natural and gradual hydration, however, unless the sodium hydroxide, carbonate or sulphate is washed out by excess of water, which is difficult to do. Mixtures containing above 4 per cent of silicate show strong efflorescence, which is particularly marked with that made with 20 per cent aqueous solution of silicate. The silicate of soda setting is at first due purely to double decomposition of sodium silicate and calcium hydroxide. If very strong silicate is used the mass stiffens so fast that it cannot be worked. This is true of all concentrations of 50 per cent or over.

There is one point that might be noted. For immediate immersion in running water silicate of soda acts as a binder, while the particles of the cement form gelatinous colloids instead of being washed away. The soluble sodium salts are more or less eliminated and apparently normal concrete results. I have used glue solutions (3 to 5 per cent strength) with white Portland cement to secure very dense compositions. It is possible that the glue aids colloid formation, and protects the same against too rapid crystallization.

*Oil Proof.*—(*a*) Several of the best known lutes I am placing under this category, although they might be classified elsewhere:

| | |
|---|---|
| Good glue | 2 parts by weight |
| Glycerine | 1 " " " |
| Water | 7 " " " |

The glue is first softened by the water, then liquefied by heat and the glycerine incorporated. This is a good lute to render corks vacuum tight, for stopping small leaks of almost anything except water and steam.

(*b*) The following has been found useful in laboratories and in the works for oil vapors:

Putty of molasses and flour.

(*c*) The next lute to be mentioned is one of the best known and most useful. The proportions given are those I have found satisfactory:

| | |
|---|---|
| Glycerine | 90 parts by volume |
| Water | 10 " " " |

To be made into a stiff putty with

| | |
|---|---|
| Litharge | 90 parts by weight |
| Red lead | 10 " " " |

It takes several hours to stiffen and about a day to set.

(*d*) Several cements of which silicate of soda is an active principle or the chief binding substance are as follows:

Silicate of soda (about 30 deg. Bé.)
Whiting

Made into a stiff putty.

This slowly sets by drying if not by chemical action. If magnesium carbonate be used the setting is so quick that it is hard to use the mixture. If it is used, however, the silicate should be diluted to one third to one half normal strength. I do not recommend either of them.

(*e*) Barium sulphate is often used with silicate of soda. The silicate should be about 30 deg. Bé. If the mixture is heated by a preliminary heating of the silicate or it is put in a hot place there seems to be some chemical reaction which aids in the setting.

(*f*) A very strong and ultimately hard cement or substance for a variety of purposes is made by incorporating glue with plaster of Paris. This will be described with other plaster practices in Section 6.

*Acid Proof.*—(*a*) The asphaltic preparations referred to in Section 1 are largely acid proof. Black putty, the formula for which was first noticed by me in a "Handbook of Chemical Engineering," by George E. Davis, is made by intimately mixing equal weights of China clay, linseed oil and gas-tar. The ingredients must be anhydrous, so it would probably be best to take a tar residuum or very soft pitch of thick, so-called, creosote oil. Rubber cements may have varied composition, but I will only refer to two which are, perhaps, extremes. If equal parts of fresh unvulcanized rubber are used the mass is so stiff that it would be probably used alone. If as much as four parts of linseed are used considerable filler can be incorporated and make a workable putty.

(*b*) Equal weights of rubber and boiled oil are taken; the rubber is first dissolved in carbon disulphide in the proportion of 4 cubic centimeters carbon disulphide to 1 gramme of cut-up rubber. Boiled linseed oil is then nixed in, and the mixing is facilitated if the oil is warm. The solvent is generally not removed by evaporation until the paste is applied.

(*c*) The other formula, to which reference has just been made, differs in having four times as much boiled linseed oil and then fire clay or other filler, such as silex, is used.

| | |
|---|---|
| Crude, finely cut rubber | 1 part by weight |
| Linseed oil, boiled | 4 " " " |
| Fire-clay | 6 " " " |

(*d*) Melted sulphur with fillers of stone powder cement, sand, etc., are used. The following is used for hydrochloric acid vapors:

| | |
|---|---|
| Rosin | 1 part by weight |
| Sulphur | 1 " " " |
| Fire-clay | 2 " " " |

Linseed oil (boiled) and fire-clay stand most acid vapors.

(*e*) According to Davis red lead and litharge in boiled oil stand acid vapors (even nitric acid).

| | |
|---|---|
| Litharge | 80 pounds |
| Red lead | 8 " |
| Flock asbestos | 10 " |

Fed into a mixer, a little at a time, with 6 quarts of boiled linseed oil.

There are numerous acid-resisting mixtures possible in which silicate of soda is used. This is possible, in spite of the strong basic character of silicate of soda, because the silicate is superficially changed to colloidal silica, which continues the cementing work, at first effected by the silicate of soda.

(*f*) Barium sulphate, powdered glass, China clay, etc. are used with silicate of soda slightly diluted with water. A strength of about 30 deg. Bé. is close to what is best for the purpose.

(*g*) The following I have used with success for dilute hydrochloric acid:

| | |
|---|---|
| White China clay | 1 part by volume |
| Fine white sand, or powdered quartz and sand | 2 " " " |

are mixed thoroughly and worked up with just enough silicate of soda, diluted with an equal volume of water to make a paste. This can be rendered more impervious to water by the judicious incorporation of organic colloids. If a little fine casein be incorporated with the silicate of soda in a mixer so that the mixture is quite smooth the mass will be better. About 5 per cent of fine, dry casein powder is added, based on the weight of silicate. If fresh milk curd can be used, corresponding to the same dry weight of casein, and allowance is made for the water contained, a mechanical mixer may not be needed.

*Chlorine Resistant.*—(*a*) The most reliable are made with Portland cement as chief ingredient:

| | |
|---|---|
| Powdered glass | 1 part |
| Portland cement | 1 " |
| Silicate of soda | 1 " |

The last mentioned should be diluted considerably so as not to set too fast.

Portland cement quickly reacts with silicate of soda, but powdered glass and clay react more slowly with silicate of soda, but finally render the cement insoluble as regards its mass.

*General Purposes with Plaster of Paris.*—This series of lutes and cements is highly important, and individual formulas will serve to prevent the escape of hydrocarbon and other gases in furnace work, as cements for mechanical purposes and as coatings, such as plaster, when mixed with asbestos straw, plush trimmings, hair, etc.

(*a*) Soluble sulphates form double sulphates with cal-

*A paper read at the Baltimore meeting of the American Institute of Chemical Engineers.

cium sulphate and with water. They set harder and are more impervious than calcium sulphate (plaster of Paris) alone. It is desirable not to take equal molecular quantities to form the full double sulphates, but about half of these quantities. Sodium, potassium and aluminium sulphates are used for this purpose.

(*b*) According to Sigmund Lehner, a little borax in the water used makes hard cements and regulates the setting: 12 volumes water to 1 volume saturated borax solution sets in 15-20 minutes at 10 deg. Cent.; 8 volumes water to 1 volume saturated borax solution sets in 1 hour. The same author gives a formula credited to Viotti for a weatherproof plaster cement.

(*c*) One thousand five hundred grammes of borax and 150 grammes of magnesium oxide are melted together and powdered. This powder is then mixed with 75 grammes of plaster of Paris. Borate of magnesium thus predominates and protects the plaster from being washed away by water.

*Marine Glue.*—Standard preparation of this class of lutes (which are applied to crevices, etc., hot, and get firm but not brittle when cold) is composed as follows:

| | |
|---|---|
| Crude rubber | 1 part by weight |
| Shellac | 2 " " |
| Pitch | 3 " " |

The rubber is first dissolved in carbon disulphide or turpentine before mixing with the heated (not superheated) mixture of the other two. The advent of blown petroleum residuums has made it possible to make up hard but flexible compounds without rubber. Grahamite is a good base to which fluxes, such as these just mentioned or soft asphalts, are added.

*Gasket Compositions.*—There are so many good gasket compositions on the market that I was on the point of omitting all reference to them. For factory work I have found no trouble in getting ropes of graphitized asbestos, rubber composition, leather fibers cemented with rubber, etc., that are quite satisfactory.

In the laboratory one can generally make out for low temperatures and pressures by saturating heavy "kraft" wrapping paper with soft pitch, such as wood pitch for steam or with gelatine and glue (hektograph) composition for oils. For high pressures, slots filled with lead rings and a V-shaped rim to the lid are most satisfactory.

*Machinists' Cement.*—A few words might be said here with reference to machinists' cement. These are the well-known red and white leads. The red lead is often diluted with an equal bulk of silica or other inert substance so as to make it less powdery on drying. The best way that I have found to accomplish this, however, is to add rubber or gutta-percha to the oil as follows:

| | |
|---|---|
| Linseed oil | 6 parts by weight |
| Rubber or gutta-percha | 1 " " |

The rubber or gutta-percha is dissolved in sufficient carbon disulphide to give it the consistency of molasses, mixed with the oil, and left exposed to the air for about 24 hours. The red lead is then mixed to a putty. Oxide of iron makes less brittle cements than red lead.

*Leather Cement.*—As cements of this class are apt to be wanted by chemists sometimes, I quote from my paper in the *Transactions* of the Engineers' Club of Philadelphia, xxi, 4, 1904.

The following formulas are given in the *Papier Zeitung*, vol. 18, p. 2618:

"(*a*) Equal parts of good hide-glue and American isinglass, softened in water for 10 hours and then boiled with pure tannin until the whole mass is sticky. The surface of the joint should be roughened and the cement applied hot.

"(*b*) One kilo of finely shredded gutta-percha digested over a water-bath with 10 kilos of benzol, until dissolved, and 12 kilos of linseed oil varnish stirred in.

"(*c*) Seven and one half kilos of finely shredded india-rubber are completely dissolved in 10 kilos of carbon disulphide by treating while hot, 1 kilo of shellac and 1 kilo of turpentine are added, and the hot solution heated until the two latter ingredients are also dissolved." Precautions against fire and vapors should be observed.

(*d*) Another one noticed in the *Journal of the Society of Chemical Industry:*

| | |
|---|---|
| Gutta-percha | 8 ounces |
| Pitch | 1 " |
| Shellac | 1 " |
| Olive oil | 1 " |

These are melted together.

*Iron Cements.*—When iron in a fine state of division, as in fresh oil-free filings or cast-iron borings that have been powdered, is mixed with an oxidizing agent, such as manganese dioxide or a substance electro-negative to iron, such as sulphur, in a good conducting solution like salt or salammoniac, galvanic action sets in very rapidly, ammonia is given off (if salammoniac be used) and the iron swells, by forming iron oxide, and cements the mass together. It is best diluted with Portland cement. A formula which I give from memory is:

| | |
|---|---|
| Iron filings | 40 parts |
| Manganese dioxide, or flowers of sulphur | 10 " |
| Salammoniac | 1 " |
| Portland cement | 20 to 40 " |
| Water to form a paste. | |

These cements are used extensively in foundries, etc.

I prefer managanese dioxide to sulphur as a negative element. The free carbon of cast iron that has been powdered is negative pole enough to react, but the use of manganese dioxide causes quicker action. If not diluted with cement they are apt to expand too much and bulge out from the hole or crevice in the iron.

*Crucible Cements.*—(*a*) Mixtures of clay and borax in which the clay predominates. Silicate of soda and powdered glass or sand are the best known compounds for cementing lids on crucibles, etc. Sometimes the "iron cements" are used for such purposes, or iron filings and a little manganese dioxide are added to the above compositions for crucible cements.

(*b*) Probably the best known cement for graphite is fire-clay, which with water binds the graphite fairly well and itself stands high temperatures.

(*c*) In some cases it is desirable to have an all-carbon binder, and for this purpose tars or soft pitches are used. Very little binder must be used, however, or the material will crack when heated, as the carbonizing of the pitch shrinks the binder somewhat. Starch paste has been recommended for this purpose, but the shrinkage is greater and the binding is not as good.

(*d*) A strong, waterproof cement that will stand high temperatures may be made by mixing powdered silica or fine sand and powdered silica with a solution of magnesium chloride of about 10 per cent strength. This composition is applied as a putty and then painted or soaked in a solution of silicate of soda of about 30 per cent strength. This forms magnesium silicate as a binding material for the silica.

*Magnesia Composition for Furnaces, etc.*—Magnesia burned at incandescent heat or hard-burned, 80 per cent. Magnesia light-burned (just sufficient to drive off carbon dioxide, dull redness), 20 per cent. The composition is made into a stiff putty with water and shaped as desired. The water must be driven off very slowly. A small proportion of good asbestos fiber may be worked in to keep from cracking.

*Oxy-Chloride Cements.*—These are sometimes called stone cements and the only one of practical importance is that made with magnesium chloride.

If the magnesium chloride is quite pure, i. e., free from potassium or calcium chloride, the solution used need not be more than 18 deg. Bé., but if commercial German magnesium chloride be used it requires a solution of 20 to 22 deg. Bé. The magnesium oxide must be freshly burned at a dull red heat as the light oxide that is requisite for this cement readily absorbs carbon dioxide from the air and becomes unsatisfactory or of no use for making cement compositions. A diluent for the magnesium oxide is generally used, such as silica or wood pulp, ground wood, etc.

This communication is not offered as being an exhaustive treatment of the subject, but as an attempt at bringing together only tried or traceable formulas, for the making and using of lutes and cements.

## The Part of the U. S. Coast and Geodetic Survey in the Development of Commerce.

At the Centennial Exercises of the United States Coast and Geodetic Survey, held at Washington, on April 5th and 6th, the Hon. J. Hampton Moore, member of Congress from Pennsylvania, made an important address on the above subject, a synopsis of which is as follows:

Mr. Moore spoke of the relation of the Coast and Geodetic Survey to Commerce, and after paying high tribute to the perseverance and loyalty of the men of the service, said that commerce itself did not fully appreciate the importance of the work. Among other things, he referred to the formation of shoals and the location of rocks that impede navigation.

I am interested in the safety of life and commerce on all our coasts, but by reason of familiarity with the Atlantic Coast, I may be pardoned for calling attention to a few of its needs. Suppose some day, as many experts think probably, the Caribbean Sea should become the base of a great naval warfare. Florida undoubtedly would become a center of American activities. Her inland waterways, so far as they are fit, would be serviceable for supply and munition ships, and for small vessels of the Navy. We cannot count too much on these waterways now, for they have not been improved as they should have been. But what layman ever knew, or knows now, that the Coast and Geodetic Survey has 172,000 square miles of hydrographic surveying ahead of it before all sides of Florida are covered?

Our needs by way of protection against reefs and shoals around the Florida coast are far more extensive than they are in the Alaskan waters, and yet in Alaska but eight per cent of the navigable waters have been surveyed to the satisfaction of the bureau.

The dangers of Cape Hatteras are known to every American, and the currents that abound on that treacherous coast demand the frequent inspection and oversight of the chart makers. Just above Hatteras, along the North Carolina coast, the shore line is constantly changing, as is well known. Inlets close and open according to the whims of nature. It is an interesting historical fact that no living man is now able to locate the inlet through which passed the Sir Walter Raleigh expedition, which made the first English settlement on Roanoke Island in 1584. That the vessels of Amadis and Barlow entered Croatan Sound is well established, but the channel through which they came has long since disappeared.

The closing of inlets as far north as New York has not been of infrequent occurrence in the course of the last century, nor has the accretion or recession of land where the waves and storms have played upon it.

Near Chincoteague Inlet, Virginia, is a comparatively new harbor, known as the Assateague Anchorage. It owes its existence to a natural change in the coast line at the south end of Assateague Island, which has converted an exposed bight into a well protected and much frequented harbor. This harbor is preferred by local shipping to some of the artificial harbors of refuge along the coast. It has an added importance because it is the only harbor between the entrances to the Chesapeake and Delaware bays, but it must be examined frequently in order that the shifting sands may be so charted as not to deceive the mariner.

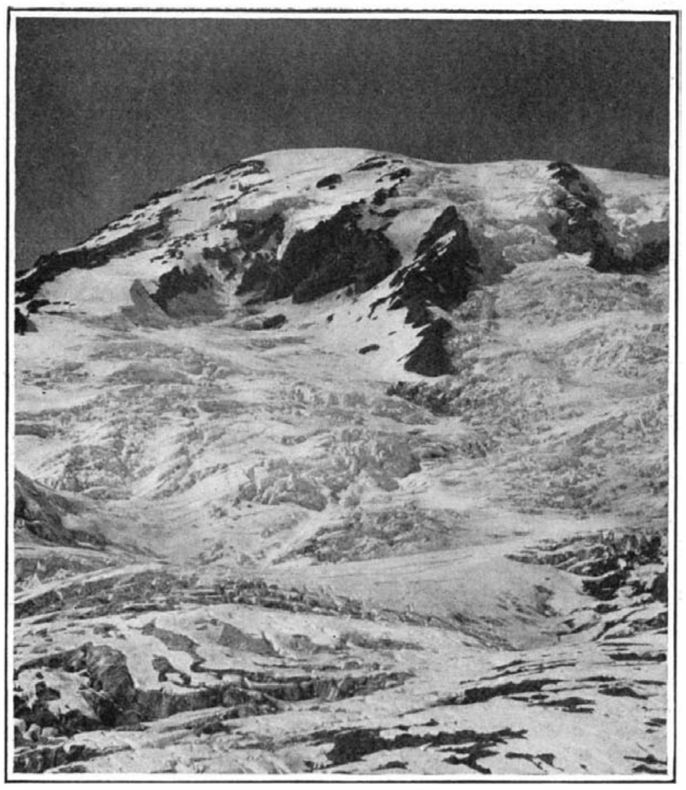
Advancing along the coast to the New Jersey and Delaware shores, where shipping increases, it is observed that at the present time the Coast and Geodetic Survey stands in need of funds to survey and resurvey about 13,000 square miles off shore. There are shoals constantly forming on these shores which should be examined and charted in the interests of navigation. This is an area which is presumed to have passed the pioneer stage, but it evinces that same disposition to conform to the forces of nature that prevail in less frequented waters.

More remarkable than this, however, is the situation with respect to the waters approaching the great metropolis of New York. The Rivers and Harbors Bill, now pending in the House of Representatives, carries an appropriation of $700,000 to extend and deepen the channel from the sea to the Brooklyn Navy Yard, a very important work that should have been completed long ago. The reason for this appropriation is that there are obstructions in the channel, possibly of rock foundation, which make navigation perilous for the dreanoughts of the Navy. When vessels of 12 feet draft were sailing into New York harbor it made no difference about this channel, but the increase in the size and draft of vessels has made a difference, and the lead and the drag must be invoked again.

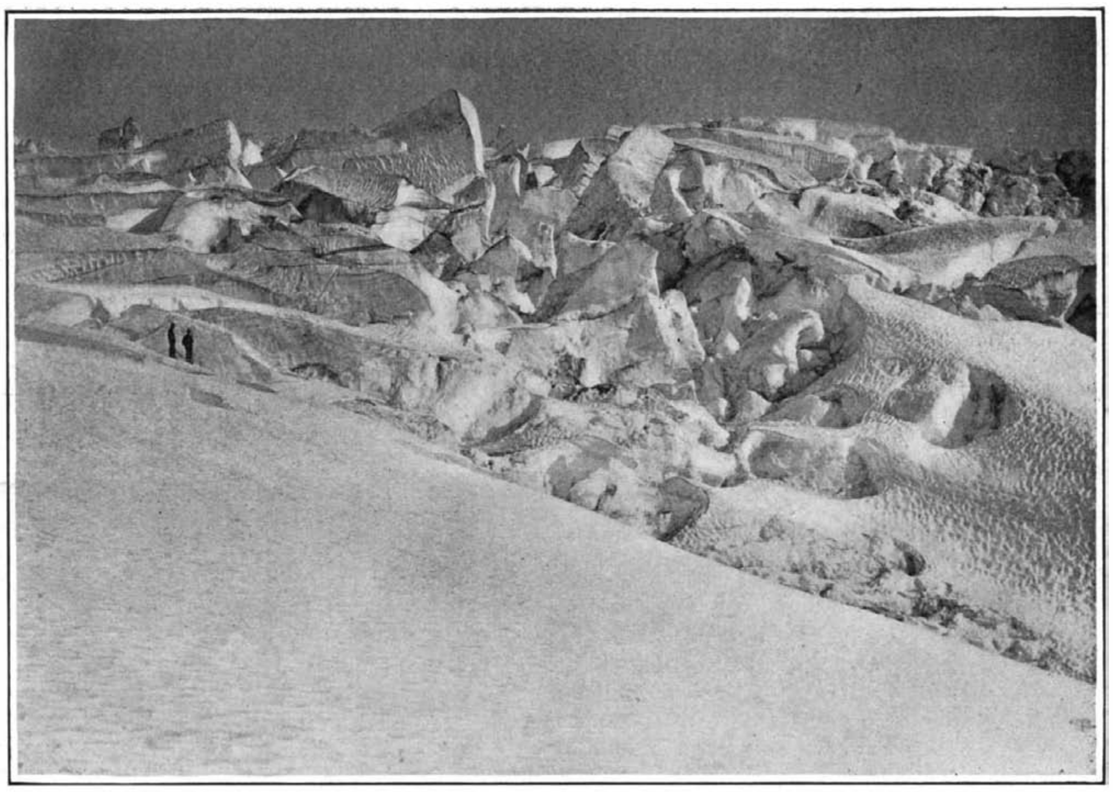
There are rocks in the East River as every one knows. Some of them are of the pinnacle type, and strange as it may seem, have only recently been located. As late as 1915 the wire drag was used by the Coast and Geodetic Survey in the East River, locating certain dangerous shoals which are a menace to navigation, and which in the event of war would seriously handicap our battleships. If commercial New York, exposed as it is to the guns of a hostile fleet, is just beginning to make discoveries of new formations and obstructions in its waterways, it is high time that the people elsewhere along our coast lines should wake up to the importance of increasing and developing the coast and geodetic service.

I have not time to further discuss the work along the Atlantic Coast, except to say that the Maine waters abound in rocks and shoals. The wire drag service is badly needed there, as it is all along the New England coast. The report of a recent survey in the vicinity of the Rockland Naval Trial Course discovered no less than four shoals, on any one of which a battleship might have been seriously damaged. It is noteworthy also that in a survey of the approaches to Narragansett Bay, one of our most beautiful sheets of water, evidences of hidden formations were discovered. As late as 1914 the wire drag party found no less than fifty shoals at the entrance to Buzzards Bay, from which vessels now pick their way into the newly constructed Cape Cod Canal.

**The Gas Pressure** in a tungsten glow lamp when the lamp is cold is about one half or two thirds of an atmosphere. Even when hot there is no great excess of pressure, and therefore no fear of an explosion.



**A glacier on Mount Ranier.**



**Giant crevassing of Norma Glacier in Alaska, showing its rapid movement.**

# Some American Glaciers

## Alaska and the Northwest Coast Furnish Varied Specimens

By Carlyle Ellis

GLACIERS are more than mere curiosities or playthings. There was a glacier once that was a veritable gold mine. It was in the days of '49. San Francisco was a "good" town then, which is to say that nothing was too good for the men who were there, because most of them had a good deal more money than was good for them. The prices they paid for luxuries in those days were appalling, and the greatest of all the luxuries was ice to cool the other luxuries.

So it came about that an ice company was formed, ships were chartered, an Alaskan glacier was captured, cut up and shipped two or three thousand miles to that superheated mining metropolis. That is, it was shipped a little at a time. A few shiploads didn't alter it perceptibly. At least, they had not when the game played out. But it was a gold mine while it lasted.

At that, glacier ice mining is only in its infancy in Alaska. The Yankee soldier boys at Fort Liscum, across the bay from Valdez, supply the fort with glacier ice, to-day. Their method is simple. Shoup glacier discharges into an arm of the bay not far off. They take a scow over there, select the icebergs of the right size and shape and haul them aboard.

The town of Valdez nearby has a glacier of its own that is unique for its accumulation of human history.

During the Klondike rush of 1898 several thousand stampeders, with their outfits, were dumped on the beach at Valdez, it having been gathered by looking at a map that this was the nearest seaport to the gold region. The literally trackless wilderness in between might have been so labeled on the map, but it was not. Even in summer there was no trail at all, and this happened in the depth of winter.

"Which way do we go?" was the cry of the thousands on the beach.

"Over the glacier," was the answer. That was about as near as anyone could come to an answer, and perhaps it was as good as any.

Over the glacier was 21 miles. "Easy!" said the argonauts cheerfully. From the glacier to the gold fields was a thousand or more far worse miles, but few knew or thought of that. So the thousands hurled themselves and their thousands of tons of supplies at Valdez glacier. The snow was deep and traveling fairly safe. The trail was soon well worn.

Many of the over-laden parties spent heart-breaking weeks getting their stuff up the first 200-foot slope of the glacier. It was killing work for green men, and took every ounce of pluck out of many. But there was 5,000 feet of climb in the next 15 miles. Think what that meant!

They began to quit before they were well started, and they were quitting all the way to the wind-swept summit where 90 feet of snow falls in the year and one camped half the time in blizzards that no man could face. But once over the summit they overloaded their sleds and started gaily down the treacherously steep slope. Sled after sled was dashed to pieces and buried beyond hope in avalanches of snow.

Wherever men quit they left their outfits. The glacier trail was lined with hundreds of tons of costly stuff to be had for the taking and there were rich pickings for those who stayed behind in Valdez to trade. The supplies were the mainstay of the town for a year or two.

Only a few hundred of those thousands ever reached the gold camps. Most of those who did not turn back in the face of that white, awful summit, stopped, worn out, to wait for spring on the other side. There they built cabins, prospected a little and lived on the reduced supplies till they were gone. Then they started back light over the glacier trail.

**Morainal fan of Valdez Glacier.**

Not in all that mad stampede was there madder folly than this. Remembering bitter camps in that ice-filled pass, they deliberately waited for warmer weather to return. Amazing ignorance of the ways of glaciers!

As soon as the snow on the ice of Valdez began to melt under the spring sun, the water began washing out the choked crevasses. Before long there was a thin, inviting shell of smooth snow over a very labyrinth of deep ice caverns. A pebble might break the bridges of this frightful devil's trap or a man's weight. And back over them came desperately reckless men in hundreds. Nobody knows how many went down, but Valdez accounts for twelve and always adds "at least." They are all there yet, in a state of excellent preservation. But Valdez glacier is melting down year by year, and some day they will be reached and they will not have changed at all.

Valdez is a "dead" glacier—that is, it is moderately dead, for the glacier quality of deadness is entirely relative and far from final. At its foot (where its face is, if it has a face) Valdez is unmistakably defunct. The "foot" spreads out fan-shaped and curves downward to the plain, its irregularities of contour looking like the toes of some gigantic reptile. With its scaly covering of blackish slate that glistens in the morning sun, the resemblance is overwhelmingly vivid, and one hesitates to stop on the great toes that have buried themselves in the drift, as if they might begin to draw up under the touch. That, of course, is hardly an impression of deadness. The impression follows. You near the great silent ice across the raw, ugly flats where nothing grows and nothing moves. You step gingerly to the ice, half expecting something cataclysmic to happen. Nothing does happen and you grow bolder. You stamp and strike the monster with your stick. You roll stones down its steep sides and go awesomely on upward. At the top of the first slope you sit down to rest and look about. In the stillness, you notice another phase of the glaciers' relative deadness. It is making a good deal of ghostly noise. There is muffled roaring in its depths and queer unaccountable cricks and booms. Intermittently comes the sliding of gravel or the bumping of a rock down a slope. The sounds seem to multiply in the stillness till your thumping heart drowns them out. A lonely place is a glacier!

The exposed top of the ice is not, as you expected, smooth and clear, but coarsely granulated by the sun to a sparkling whiteness. In this are queer potholes filled with crystal water.

One part of Valdez glacier was covered when I last saw it with conical piles of gravel that looked like high ant hills. I kicked one, and found it a counterpart of the ancient brick-under-a-hat of April first. It was very, very solid. Scraping away the gravel, a cone of clear ice was revealed. I asked questions.

"They're reversed holes," said my guide. And he meant it—just that. When a hole melts in the ice, all the gravel in it, of course, slides to the bottom. Then, by and by, the surrounding ice melts down to the hole. The gravel in the center protects it there so that the bottom of the hole is eventually above the general ice level.

The most beautiful and dangerous feature of a glacier is its crevasses, and they are endlessly fascinating. The ice of a crevasse never seems to be transparent, but rather is opalescent, and the color is a wonderful luminous blue that is not just the blue of the sky, but is quite as beautiful. Sunlight seen through glacier ice makes it a clear greenish blue, and a sun shadow on the ice runs to purple, but the blue of the depths is as pure a color as that of the sky. Its quality is nearest to the iridescent flash of the little known stone called labradorite—like a blue flame.

In deep crevasses, the outlines of the ice are almost lost in the glow of pure color, and this adds to their evil fascination, but it breaks the spell to drop a stone down the perpendicular sides and hear it bound and rebound until the sound is lost in the deep rumble of waters under it all. Then one draws back.

The presence of these fissures is a sure sign that there is or has been, not long ago, movement of the ice, as was interestingly established by Profs. Tarr and Martin in their investigation of Alaskan glaciers.

In 1899 there was a series of violent earthquake shocks in the heavily glaciated Yakutat Bay region. At that time nearly all the glaciers of the region were dead or relatively so. The next year, half a dozen of them came to life and began to travel at considerable speed.

For several years after that there were added revivals. Then the excitement began to quiet down. The glaciers began to settle back in their beds and now most of them are again in the sleep that is called death.

One of the odd points about this movement was that before the glaciers began their sudden forward movement they were smooth-topped and could easily and safely be crossed on foot. A few months later they were a sea of impassable crevasses, a forbidding and terrifying spectacle. But as soon as they stopped flowing they began to melt off smooth again.

The scientists decided that it was not alone the jogging the glaciers had received that awakened them, but something they named glacier floods. The earthquakes loosened avalanche after avalanche from the mountain sides and these piled up to enormous depths on the sleeping ice rivers. The extra covering disturbed their equilibrium or whatever it is that keeps them asleep and they began to kick out from under.

In some cases they worked forward two or three miles in a season, calmly and effectively removing not only forests but all the soil as well.

When glaciers are traveling at this rate look out for them. This advice is really superfluous for there are few things more terrifying in nature than the ceaseless roaring grind of a rapidly moving ice-body two or three hundred feet thick and miles across.

Even the inquisitive scientists, who are not ordinarily timid persons and who have come nearest of anyone to domesticating the ice-brutes, fought shy of the maw of Atrevida in Yakutat when it ran amuck in 1906.

When a glacier faces on the sea or a river, it is, of course, a different matter. Then the water washes away the loose ice and the result is a perpendicular face often 300 feet high. If you figure the Palisades of the Husdon done in clear turquoise-colored ice, you will get quite an idea of what the faces of a dozen glaciers in Alaska look like.

But, unlike the Palisades, the glaciers are advancing, so all through the summer their faces keep peeling off, often a few thousand tons at a time, and the noise they make doing it has an ordinary thunderstorm beaten to a whisper. Ocean-going excursion steamers stand off a couple of miles from a berg-discharging glacier, but a stout, seagoing ship's boat may venture in within a half mile or less, if there are no tourist passengers.

**The dead foot of Valdez Glacier.**

There is one place in the world where you may watch these monster volleying bergs at close quarters. To be precise, the exact distance to which you may approach is 1,300 feet, being the width of the Copper River—for this place also is in Alaska—plus 100 feet of steep bank. The glacier is Childs and the observation point is only a few feet from a railroad.

The glacier looms above you as do the Palisades when you are in midstream of the Hudson, and every few minutes there is the rattle and boom of falling ice. One of the most exciting—and safest—sports in the Northland is snapping at these outbursts with a fast camera. It takes quick work, for one can never guess where the next one is to be and good pictures of the ice-falls are rare.

One does not have to go to Alaska or Switzerland to see glaciers. You might imagine from all that has gone before that Alaska had a monopoly of them. True, they are many and big up there, but right here in the United States within easy reach are many that are big enough and well behaved enough to make excellent companions. They are often surprisingly available, too. The mountains of the Northwest are well stocked with them. Mt. Tacoma, for example, has four or five of great size and extraordinary beauty, and you can get to within a short walk of the mountain by railroad and automobile from Seattle. Mt. Hood, in Oregon, with its glaciers, is equally easy to reach and so is Mt. Baker to the northward.

The glaciers of these great peaks are far steeper and wilder than the bigger, tamer ones of the northern valleys. Most of them are hanging and some are cascading glaciers. That is an inviting name for a glacier—cascading—and is often accurately descriptive. It means that the glacier is living and discharges ice over a cliff or down a mountain slope. But it also generally means that the glacier bed is very steep and the movement comparatively rapid. This means tremendous crevassing of the most widely picturesque kind. There is a glacier on the north side of Mt. Adams, in Washington, that falls steeply for two or three thousand feet and it looks from a distance like a great white mountain torrent billowing madly in a literal cascade.

You will hardly get above the 6,000-foot level anywhere in these northern mountains without finding glacial ice and it takes a comparatively insignificant glacier to give one thrills, if it is your first.

## The Dangers of Rubber Manufacture*

THE rubber industry in the United States is important, employing tens of thousands of men and women, and increasing continually. Whether or not it is attended with risk to the health of those engaged in it, and is to be classed as a dangerous trade, most of us would be unable to say. In Germany and France it is considered a decidedly dangerous trade, and many cases of poisoning from carbon disulphid used in vulcanizing rubber are recorded in the literature of those countries. In one rubber manufacturing city, Leipzig, Laudenheimer[1] found fifty cases of carbon disulphid insanity in Flechsig's clinic, and this substance is still largely used in German rubber works. In a recent publication[2] are described eight cases of mental breakdown among thirty men who were using carbon disulphid in pasting rubber strips on belting. In the British reports of earlier years, this poison and naphtha (used in making rubber cloth with a paste of rubber and naphtha) were said to be the cause of much ill health and serious nervous troubles among girls especially, and though the use of carbon disulphid has been largely given up now, the fumes of naphtha are still a troublesome feature in British rubber works. Another volatile poison frequently mentioned in continental reports is benzene (benzol, $C_6H_6$), more poisonous than benzin and naphtha, and cheaper than the latter over there.

A bulletin dealing with the use of poisonous substances in the rubber industry in this country has just been issued by the Federal Bureau of Labor Statistics[3] as part of a series on industrial accidents and hygiene. The basis of this report is an investigation of rubber factories in different parts of the country manufacturing all varieties of goods. It is surprising to learn that so many poisonous substances are used in this industry. The list includes lead compounds, such as litharge, the basic sulphate of lead, the basic carbonate of lead, and red lead; anilin oil; sulphids of antimony; petroleum products; coal-tar benzene; carbon disulphid, and carbon tetrachlorid. In addition to these compounds, concerning which definite information could be obtained, Dr. Alice Hamilton, who prepared the report, learned of the use, in reclaiming rubber, of various phenols of different degrees of crudity, and also of pine oil, turpentine, tar, and a product of the action of carbon disulphid on anilin known as thiocarbanilid. The rubber industry has many trade secrets, and information about all the compounds in use, especially in rubber reclaiming, was difficult to secure.

In spite of this array of poisons, the report does not characterize the rubber industry in this country as an inherently dangerous trade. What danger there is, and it is evident that most factories are far from safe in certain departments, comes from carelessness in the handling of poisons so that preventable dusts and fumes are allowed to escape. This was found to be true in almost all the factories inspected, even the best. That such accidents are not more generally known is explained by the fact that out of the whole force in a plant only a small proportion engage in work exposing them to poisoning, so that even if the sickness rate among them is high, it makes little impression.

In comparing American methods of manufacture with the European, the advantages are seen to be on the American side. We do not use carbon disulphid in vulcanizing to any great extent. Dr. Hamilton states that she found only 130 men using this substance in all the factories visited, and she contrasts this with a statement of the German factory inspectors' report for 1910 concerning a single factory in which the installation of a certain machine had replaced the work of 150 women vulcanizers. No women do this sort of work in America. Another reason for the comparative safety of rubber work in America is that most of our rubber cloth is made on calenders, by pressing thin sheets of rubber into the fabric, and then vulcanizing by heat. In England and on the Continent the usual method is by "spreading," that is, pressing a paste of rubber and naphtha or benzene into the fabric and then letting the volatile part evaporate, and finally vulcanizing by means of carbon disulphid. This method is used also in America, but only exceptionally, as benzene is too expensive to be used in large quantities.

These advantages are great, yet according to the report they are not sufficient to make the industry altogether free from danger, in the absence of proper precautions. Consequently lead poisoning is not uncommon among the men employed in compounding rubber and mixing it on the mills. Acute, severe benzin or naphtha poisoning is said to be rare, but mild chronic poisoning is probably very common among the men and women who apply rubber cement. The toxicity of antimony pentasulphid was so much in doubt, being practically ignored by the toxicologists, that the bureau asked Prof. A. J. Carlson to determine whether or not there was any danger in the use of this compound. Carlson's report is found in the appendix to the bulletin. He tested the golden and the crimson sulphids with human gastric juice, and found that about 3 per cent of the former and 8 per cent of the latter passed into solution, showing that there is a possibility of poisoning in the case of workmen exposed to large quantities of the dust, as is true in rubber compounding.

Carbon disulphid is said to be unknown as an industrial poison to physicians in this country, even to those in rubber towns; yet the investigators were able to discover cases of carbon disulphid psychosis and paralysis among the vulcanizers of dipped goods and the splicers of inner tubes for tires. Dr. Hamilton suggests that other cases would perhaps come to light if the industrial history of the inmates of certain Ohio insane asylums were studied as Laudenheimer studied those in Leipzig.

Carbon tetrachlorid is a new substance in the rubber industry, introduced because of its non-inflammable character to take the place of the highly inflammable carbon disulphid as a vehicle for sulphur monochlorid in vulcanizing thin or highly colored goods, or in splicing inner tubes. Waller[4] in England and Lehmann[5] in Germany have shown that it is decidedly toxic; according to the former twice as toxic as chlorform, according to the latter rather less so than chloroform.[6] It is less dangerous, however, than the disulphid.

Anilin oil, also unfamiliar as an industrial poison in America, is shown to be fairly common, especially in tire works and in the reclaiming of rubber, and it is said that the exposure to anilin fumes is increasing since we have had to begin to manufacture our own anilin, the German supply having been cut off. This is an insidious poison, for the odor is pleasant and the fumes do not give warning of their harmfulness by irritating the eyes and throat, as do most volatile poisons. Cases of anilin poisoning are said to be well known in Akron, Ohio, and the victims are referred to as "blue boys," from the cyanosis which is the most striking symptom. The researches of Lehmann are quoted to show that very small quantities of anilin are needed to produce toxic symptoms, and a study of anilin poisoning in Akron plants by Rey V. Luce is appended to the bulletin.

The rubber industry is thus seeen to be a fruitful field for the study of some of the rarer industrial poisons. Nor do the ones described here complete the list. New compounds are continually being introduced and experimented on, some of them substances about which very little is known. Medical research on the effects of these substances on the human organism should keep pace with the chemical research into their value as compounds or vulcanizers.

* From the *Journal* of the American Medical Association.

[1] Laudenheimer: Die Schwefelkohlenstoffvergiftung in Gummiarbeiter, Leipzig, 1899.

[2] Briau: Lyon méd., 1912, cxix, 897.

[3] Hamilton, Alice: Bull. 179, U. S. Bureau of Labor Statistics.

[4] Waller and Veley: Lancet, London, 1909, ii, 369, 1162, 1307.

[5] Lehmann, K. B.: Arch. f. Hyg., 1911, lxxiv, 1.

[6] Dr. Hamilton suggests that possibly carbon tetrachlorid may be found to resemble chloroform in producing delayed symptoms of poisoning. A recent number of the Journal of Experimental Medicine contains an article by Evarts Graham on "Late Poisoning with Chloroform and Other Alkyl Halides," in which tetrachlormethane (carbon tetrachlorid) is shown to possess even more necrosis-producing power than chloroform. The most extensive necrosis was seen after about two days. The minimum fatal dose per kilogramme rabbit is 0.085 framme for chloroform and 0.053 gramme for tetrachlormethane.

## The Cost of Mountain Railways

A WRITER in the *Electric Railway Journal* thinks the cost of building mountain railways might, in some cases, be reduced by having steeper gradients with electric traction. The distance might thus be shortened, and this with the regeneration system, makes it likely that economies could be effected in operating expenses.

# Farm Tractors*

## A Review of Their History, Conditions of Use and Methods of Construction

By Philip S. Rose

THE gas tractor has not yet become as highly developed as the automobile. Tractor motors are not standardized; nearly every known type is in use and each manufacturer declares his particular motor is either the best or just as good as any that can be built. There is just as much divergence of opinion regarding tractor motors as there was fifteen years ago about automobile motors. It is exceedingly difficult to analyze a situation which borders so closely on chaos. The new tractors brought out this spring are equipped with the following styles of motors: One-cylinder; two-cylinder-opposed; four-cylinder-opposed; two-cylinder-vertical; four-cylinder-vertical; six-cylinder-vertical; two-cycle two-cylinder-twin; and four-cycle double-twin. There is certainly enough variety to satisfy the most exacting.

In order to understand the tractor situation as it presents itself at this time it is necessary to refer briefly to history. The first experimental work in this country appears to have been done in 1898 or 1899 by Messrs. Hart and Parr, two students at the University of Wisconsin. Their first tractor was necessarily crude and people who saw it tell me that they were not favorably impressed with it. They finally went to Charles City, Iowa, and continued with their experiments. A few tractors were built from 1900 to 1905, but it was not until 1906 that they claimed to have a substantial plowing tractor. After experimenting with many types of motors they finally adopted the twin, that is, side-by-side cylinders.

About 1900 Messrs. Kinnard and Haines of Minneapolis began experimenting with a tractor, and finally evolved one having four vertical cylinders. From 1906 to 1910 the two firms mentioned had practically a monopoly of the tractor business in this country. During 1908 and 1909 a considerable demand for tractors grew up throughout the West. For a time it threatened the steam traction engine business so much that all of the old threshing machine companies began to interest themselves in gasoline tractors.

The M. Rumely Company and the International Harvester Company were the first to begin manufacturing on a large scale. The former adopted practically the same motor as that used by the Hart-Parr Company. The International Harvester Company began with a single-cylinder motor of slow speed, identical with that used for stationary purposes. Later they developed both a twin motor and an opposed motor. In 1910, 1911 and 1912 there was considerable activity in the tractor business. The tractor trade was very quiet in 1913 and 1914, except for development work, but this year it is showing signs of great activity.

Prior to 1912 all of the tractors were heavy, powerful machines designed especially for the breaking of new land. Very little effort was made to develop a machine suitable for old tilled farms. After the slump in 1912 a number of the companies, among which may be mentioned the Avery and Case, brought out machines of medium weight and power suitable for the large farms in the Corn Belt. These machines developed from 20 to 35 horse-power and were capable of hauling five or six plows.

Last year marked the advent of the very small light-weight machine, a three-wheeled tractor weighing 3,300 pounds, to be sold at retail for $335. There is now a large number of light-weight tractors on the market, ranging in weight from 3,000 to 5,000 pounds and selling at from $350 to $850. These light-weight tractors are supposed to be able to pull about two plows and do the work of three good horses.

Up to the present time there has been a good deal of invention and trying-out of new motors, but very little co-operation among designers and inventors such as has existed in the automobile industry since this society was organized. Each designer has worked independently and necessarily each one has had to learn by making errors. The design of a tractor motor appears to be a simple problem of obtaining the necessary power. Many designers have started out with that idea and invariably come to grief. The successful motor is successful only as the entire outfit is successful and it must all be designed together.

The conditions of service for tractors are more severe than for any other kind of power machinery, not excluding trucks or automobiles. The automobile motor is mounted on a spring-supported frame which is in turn supported with cushioned wheels. The truck motor, while not so well cushioned, still has the advantage of a spring-supported frame. Moreover, all of these vehicle motors are generally not required to work at full capacity for any extended period. On the other hand, the tractor motor is supported on a heavy frame mounted on rigid axles and supported, not by wheels with cushioned tires, but by wheels having lugs or grouters. Whereas the automobile motor will work on an average at one fourth or one third of its capacity, the tractor motor is expected to pull a load up to 80 per cent of its full capacity for hours at a time. An automobile running on low gear up a heavy, sandy grade is not operating under as severe conditions as a tractor motor in ordinary plowing.

It is not only the load which the tractor motor must carry hour after hour that causes the trouble. There are the vibrational stresses also to be considered, and these are very difficult to either measure or estimate. The violence of these vibrations can be understood when I tell you that it is not uncommon for the framework of a riveted frame to be shaken loose. The vibrations are not like the vibrations you have to contend with in automobile practice, but of much shorter amplitude and in the nature of a shiver rather than the undulating movement of an automobile. This constant shivering is very destructive to small cast parts, to parts not designed with a large factor of safety and to all accessory equipment. Oilers and magnetos that will give very good service in automobile practice do not always stand up when used on a tractor. The reason for the vibration is found in the hard unyielding soil, in the lack of springs and in the use of solid rigid wheels. On old well-tilled land the trouble from this cause is not so great unless the soil be baked hard or contain large-sized gravel. It is especially noticeable on the prairies and makes the use of a tractor on macadamized roads almost impossible. The conditions of traction cannot be compared at all with the conditions of carrying.

There is another feature which the tractor designer must consider and that is the fact that the probable purchaser will not be a skilled mechanic. He may not even be a good handy-man and he will not have access to a repair shop. This necessitates that the design be as simple as possible and amply strong. In view of these conditions the designers of tractor motors all agree on low rotative speeds, partly to reduce vibration and partly to reduce the necessity for large reductions of speed between the crankshaft and the driving-wheels. This does not mean that piston speeds are necessarily low. As a matter of fact they are fairly high, ranging from about 600 to 800 feet per minute. High piston speed is not undesirable, but high rotative speed is. In plowing a tractor should travel about 2 miles an hour, and on the road from 3 to 4 miles. Considering that the entire power of the motor must pass through the transmission gears continuously, it is evident that to make them sturdy enough the speed reduction should be as small as possible. There are some designers who use the same style and type of motor employed in automobiles, but those who have had the most experience use a motor that is much heavier and with larger bore and stroke. I believe that I am perfectly safe in saying that the successful tractor motor must be designed especially for the purpose and that no automobile motor, no matter how carefully constructed, can compare with a motor designed for tractor work by a competent engineer.

It is not likely that a standard type of tractor motor will be developed for several years. The leaders are very far from agreement. The twin-cylinder four-cycle motor is still used by a number of reputable manufacturers. It has the advantage of compactness and accessibility and the design lends itself particularly well to the use of valves in the head, which is universally conceded to give the greatest fuel economy. There seems to be no valid objection to the four-cylinder vertical motor when well designed and heavy enough to withstand the hard service. It does not require heavy flywheels to give proper balance, and in general has given very fair service. The principal objection which has been raised is that there is an unnecessary multiplicity of parts for the amount of power required. It is admitted that the heavy tractors need a multi-cylinder engine, but up to 30 or 40 horse-power enough power can be obtained from two cylinders.

Within the past three or four years motors of the two-cylinder-opposed type have come into extensive use and appear to give quite good satisfaction. Some designers maintain that it is impossible to hold the crankshaft at right angles to the center line of the cylinders in this form of construction. There certainly is a tendency with cylinders offset from each other, in accordance with the usual practice, for the crankshaft to wear cornerwise, and to overcome this tendency extra large bearings are essential. This type of motor is very easily balanced in the direction of motion of the piston, the small horizontal couple being quite easily taken care of, if I may judge by the steadiness of motion of the tractors equipped with this type of motor.

Where more power is required than can be obtained with two cylinders it is easy to double them up and use four opposed, in just the same way that it is an easy matter to use four horizontal cylinders side by side.

A considerable number of tractors is still made with single-cylinder motors. The limiting size for tractors so equipped is 25 horse-power. The principal objections to these machines are very heavy flywheels of considerable size and excessive weight of machine for the power developed. The twin-cylinder two-cycle engine is new. It is promising, just as all two-cycle designs are, but it is too early yet to tell much about its good qualities or defects. It shows the tendency of present-day design, at any rate, which is toward simplicity and fewness of parts.

The following table gives a very good idea of the sizes of the different types of motors employed.

| Kind of Motor. | Rated H. P. | No. Cyls. | Bore. | Stroke. | R.P.M. | Piston Speed. |
|---|---|---|---|---|---|---|
| Ver. multi-cylinder | 15 | 4 | 4¾ | 6 | 700 | 700 |
| | 25 | 4 | 6 | 8 | 600 | 800 |
| | 40 | 4 | 7¼ | 9 | 500 | 750 |
| Opposed......... | 16 | 2 | 5½ | 6 | 600 | 600 |
| | 25 | 2 | 6½ | 7 | 570 | 665 |
| | 35 | 2 | 7¾ | 8 | 500 | 667 |
| Twin............ | 40 | 2 | 8 | 12 | 400 | 800 |
| | 60 | 2 | 10 | 15 | 300 | 750 |
| Single-cylinder.... | 12 | 1 | 7½ | 12 | 300 | 600 |
| | 15 | 1 | 8 | 14 | 250 | 583 |
| | 20 | 1 | 8¾ | 15 | 240 | 600 |

In the construction of tractor motors shop practice differs slightly. Some grind the cylinders, pistons and piston rings. Others merely ream the cylinders and confine the grinding to the piston and rings. The piston tolerance is somewhat greater than in automobile motors, on account of the harder service to which these motors are subjected and the greater amount of heat which must be taken into consideration. The tolerance adopted by practically all manufacturers is 0.001 inch per inch of cylinder diameter.

Valve diameters run about 0.4 the diameter of the cylinder (being figured on a basis of gas velocities of 7,000 to 8,000 feet per minute, higher velocities being used for kerosene), with lifts about the same as in automobile practice; 3½ per cent nickel steel has been found satisfactory for the valves. Some use cast-steel heads electrically welded to high-carbon stems and these give good service, but no better than nickel steel and are not quite as substantial. Tungsten steel has been used for valve-heads, but, as is well known, the stems are liable to break off after being used for a time.

Owing to the heavy work required of tractor motors the cooling system must receive special attention. The jacket spaces around the cylinder are generally somewhat deeper than in automobile motors, and radiators, if used, must be larger and much stronger. Special care must be exercised in designing the water space around the valves. The cooling system of a tractor motor is required to dissipate from two to three or four times as much heat as an automobile motor in a given length of time, both working under ordinary conditions. The common practice of some designers is to use 100 cubic inches of water capacity per developed horse-power. This includes the space around the cylinders, the cylinder-head, piping and the radiator. Where an open radiator is used it is customary to provide for some 6 to 9 gallons of water per developed horse-power. Closed radiators usually have from 11 to 13 square feet of radiating surface per horse-power. Most tractor motors are water-cooled, circulation of the water being effected by means of a rotary pump. In the case of a few motors oil is used for cooling. Both methods appear to give equal satisfaction.

Owing to the severe service tractor bearings must be made large and supported rigidly. The length of the crankshaft bearings is generally made twice the diameter of the shaft, and the length of the crank-pin bearings from 1.0 to 1.3 times the diameter of the pin. The diameter of the crankshafts is made from 0.4 to 0.5 the diameter of the cylinders. The bearing metal used in the main bearings is generally genuine babbitt. The use of steel

* A paper read before the Society of Automobile Engineers.

shells lined with genuine babbitt in the crank-pin bearings is considered good practice. In the piston-pin bearings bronze bushings are employed.

Before the newer processes for making gasoline were discovered tractors were designed to utilize kerosene and heavier distillates. All of the medium and heavy-weight machines are still supposed to burn kerosene, and I judge from reports of users in all parts of the country that considerable success has been attained. Where kerosene is used the motor is first warmed up with gasoline and then switched on to kerosene. Some means must be employed when kerosene or heavier fuels are used to introduce water into the combustion space. This is invariably accomplished by means of a double carbureter. In plowing or hauling requiring a practically constant heavy load, kerosene can be used without much difficulty. It is only when operating on light or variable loads that kerosene gives much trouble. Considerably more kerosene is required to do a given amount of work than of gasoline. While there is a variation in the economy of different engines, it is perhaps safe to say that on an average 25 per cent more kerosene will be used, thus showing that even in the best of engines kerosene is not completely consumed. The tests made at Winnipeg in 1912 with gasoline showed that 1.846 horse-power-hours was the maximum obtained per pound of gasoline.[1] The average for all of the fifteen engines in the test was 1.5045 horse-power-hours.[2]

Compression as given by most designers is 70 pounds gage. Some of them drop down to 60 pounds when using kerosene, because of its tendency to pre-ignite at higher pressures. In order to obtain maximum economy however, they carry the compression as high as possible and then use water to cool the cylinder and prevent pre-ignition.

Some manufacturers use make-and-break ignition, but almost all of them, and especially all of the newer ones engaged in the business, are using high-tension magnetos and jump spark.

Several methods are employed for transmitting the power from the motor to the driving wheels. The old-time steam tractor used heavy cast gearing with a direct train of gears from the main drive-shaft through a differential gear mounted on a counter-shaft, from which spur pinions meshed with the bull gears attached to the rear driving-wheels. When the steam tractor was developed as a plowing engine about fifteen years ago this same train of mechanism was employed, but the gears were made much wider and instead of ordinary cast iron semi-steel was employed. This material answers the purpose much better than either cast iron or cast steel.

When the gas tractor began to be developed the same gearing was employed. It looks clumsy and is no doubt very noisy, but for the peculiar service in which it is employed it has proved quite satisfactory. For gearing exposed to dust and sand and having to transmit such enormous loads, coarse pitch and very sturdy construction are required. Some of the later models have been developed with coarse-pitch machine-cut hardened and ground gears running in oil; that is, the transmission gearing is made in this form, the driving pinions and main drive gears being invariably of the heavy cast type just described. The transmission is usually made as simple as possible. Many use the selective-sliding gear, some the planetary gear and one or two separate removable pinions of different sizes with which to obtain the necessary speed changes. Chain drive has been tried and also the worm drive, but the majority use either an all-spur-gear train or a combination of bevel and spur gearing.

[1] 0.542 pounds per horse-power-hour. 7.25 pints per horse-power-hour.

[2] 0.665 pounds per horse-power-hour. 8.85 pints per horse-power-hour.

## Annealing Furnaces*

### Latest Gas and Electric Types

ANNEALING is one of the heat-treatment processes that of recent years has been brought to an exact science. The object of annealing is to remove, by facilitating molecular readjustments, the strains resulting from the subjection of stampings, forgings, castings, or other metallic parts to mechanical work or to sudden quenching. It must be done with meticulous exactness if the greatest strength of the metal is to be preserved. The parts to be treated must be maintained at exactly the right temperature—as indicated by a pyrometer—for a very definite period of time, and in a suitable atmosphere.

The use of gas, instead of coal, for heating annealing furnaces has been an important factor in increasing the reliability of annealed parts, and in enabling the above conditions readily to be met.

Gas is being very widely used for the heat-treatment of war material in the armament works and shipyards, the very largest shells now being annealed in gas furnaces. In one huge gas furnace—so large that it had to be transported in pieces—no fewer than eleven shells, each weighing over a ton and measuring 6 feet in length and 17 inches in diameter, can be treated at the same time. At the other end of the scale we have the tiny gas-fired muffles used for the annealing of small parts of revolvers. Other classes of work treated in annealing furnaces of this type include sheet-metal stampings, many of which require to be subjected five or six times to pressing and drawing operations, and which need annealing between such operation.

For the latter variety of work the twin-oven furnaces are preferable, the top oven being used for pre-heating the articles gently before subjecting them to the full annealing temperature in the lower oven, thereby avoiding heat cracking, which may take place when the single-oven type is used.

There is often a difficulty in giving satisfactory heat treatment, followed possibly by hardening, to long metallic bodies such as axles, gun-barrels, tubes, and connecting-rods. As is well known, long metallic articles are peculiarly susceptible to distortion when being heated or cooled, and this fact has been sufficient to prevent hardening of many such bodies, or, in cases where hardening has been effected, has rendered necessary subsequent grinding. In the patented Manometer furnace, arrangements have been made which completely eliminate distortion and scaling.

The furnace is so designed that the metallic bodies during annealing and quenching are suspended in a vertical position, and, furthermore, are protected from direct contact with the flame. Surrounding the body under treatment—for example, a gun tube—is a protective sleeve upon which the flames impinge. The heat is derived from atmospheric burners of a special patented construction, which combines the advantages of low-pressure gas with that intensity of heat hitherto only associated with high-pressure gas. These burners are arranged at different heights, so that the heat, though intense, is perfectly distributed throughout the entire periphery and height of the protective tube. The top of the furnace is sealed against the ingress of air by the issuing combustion products, while the bottom of the furnace is closed by a movable partition. After the gun tube, axle, or other part has been brought to the desired temperature it is quenched by lowering into an oil tank or bosh situated immediately below the furnace. The quenching tank is mounted on a traveling carriage adapted to run on rails, and is surrounded by a water jacket in order to cool and economize the oil. The principle of excluding air is completely carried out by the provision of a tube extending from the bottom of the furnace to the top of the quenching tank. It will be apparent that the process of hardening is considerably facilitated by this furnace, and immediately the process is complete the oil quenching tank is run along the rails to a convenient point for extracting the gun tube, axle, or other metallic body. The measures which the makers have adopted appear to prevent completely the access of oxygen to the metallic body; in fact, the axle is installed in what is virtually a sealed chamber during the heating process. On some tests with gun carriage axles, for treating which a number of these furnaces were supplied, it was found that there was no measurable difference in the size and shape of the hardened axle as compared with an untreated one.

Manufactured steel, in bars, is sent out by the makers in an annealed condition, and for this purpose gas furnaces are being increasingly used. These are approximately 16 feet long, from which fact it will be obvious they consume gas on a fairly large scale. Annealing in coal furnaces necessitates packing the bars in a heavy cast-iron box to prevent scaling of the steel. This box is considered by some to be unnecessary in the gas-furnace, in view of the uniform conditions under which gas-furnaces work. The elimination of the box naturally means less absorption of heat. Decreased labor is also an important factor—in short, gas annealing has been proved very economical. In many of the smaller steel works where annealing is intermittent, the saving achieved by the use of gas-furnaces is something like 50 per cent in the cost of fuel alone—a factor in works-economy which cannot be ignored by the manufacturer in these days of keen competition.

The following are figures obtained from actual working, and are quoted on the authority of Mr. H. M. Thornton:

ANNEALING STEEL IN REGENERATIVE GAS OVEN FURNACE.

| | Carbon Steel. | High-speed Steel. |
|---|---|---|
| Weight of charge | 35 cwt. | 45 cwt. |
| Total time of heating | 6h. | 9h. |
| Time of cooling | 42h. | 40h. |
| Total time of operation | 48h. | 49h. |
| Maximum temperature attained | 880 deg.C. | 875 deg.C. |
| Gas consumption per ton of steel | 3,600 cu. ft. | 5,000 cu. ft. |
| Cost of gas per ton of steel annealed, with gas at 1s. 6d. per 1,000 | 5s. 5d. | 7s. 6d. |

Efficient though coal gas is for annealing work, even greater efficiency is possible in the case of large furnaces using producer-gas. Such furnaces have been built to consume only 1¾ hundredweight to 2 hundredweight of coal in the producer to heat one ton of metal. Theoretically, it is possible to raise 36 hundredweight of iron to welding heat by the combustion in a gas producer of 1 hundredweight of fuel. The gas-producer type of annealing furnace is now being combined with the continuous or automatic type. The open ends of the annealing chamber dip into and are sealed by water contained in tanks on both the receiving and delivery sides of the furnace. The parts for treatment are fed on to an endless conveyor which passes from tank to tank by way of the annealing chamber, returning through tunnels below the furnace and clear of the water. The drums which carry the conveyor are driven through a worm wheel on one side of the drum by a worm on the shaft. The worm is operated by a ratchet wheel, also fixed on the shaft, this being in turn driven by a pawl which receives its reciprocating motion from an eccentric attached to a countershaft. The conveyor is guided by rollers within the tanks and guide plates are provided to prevent the material fouling. This type of mechanical furnace is now in successful use in this country.

In America experiments have recently been made with electric annealing furnaces. The electrical equipment comprises a 200-kilowatt transformer arranged with twelve voltage taps, which are so operated by a special controller that a delicate regulation of the voltage, and hence the wattage, may be obtained. A watt-meter and a pyrometer are mounted on a switchboard, the latter being connected to a thermocouple placed over the tray about to be mechanically pushed out of the furnace. In this way the drawing temperature is ascertained accurately. The material to be treated is packed into steel trays or pans, 20 inches square and 3 inches high, which are automatically fed through the furnace by a pusher mechanism situated at the charging door, this mechanism being operated by compressed air. Seven pans are in the furnace at one time, and these, during their passage through the furnace, are supported on iron grids, specially designed to prevent undue warping at the furnace temperatures. The pan, as it emerges from the discharge door at the opposite end of the furnace, is automatically tipped up so that the metal falls into a tank containing either water or other liquid. The pan itself is caught on two rails and hung suspended above the trough. The discharged door is completely closed by a water-sealed hood, from which the pans are removed through a counterbalanced swing-door. The material dumped into the quenching tanks falls into a perforated copper basket. which can be removed from time to time. The mechanism is so arranged that the charging door is automatically closed, except when a tray is being pushed into the furnace, and in this way exposure of the metal to an oxidizing atmosphere at any stage between entering the furnace and being removed from the quenching tank is entirely avoided.

*Abstract from a work by Hans Zeitler from the *London Daily Telegraph*.

## Nickel Plating Aluminium

A COATING of nickel on articles made of aluminium is often desirable to prevent the oxidizing of the aluminium, which is so likely to occur on exposure to the atmosphere, but difficulties have been encountered in developing a satisfactory process, as the nickel would separate from the aluminium base very readily. It is stated that a successful process has been invented by M. J. Carnac, which is described in *Industriale Invenciones*.

The aluminium is first cleaned in a bath of boiling potash; it is next brushed with milk of lime and then immersed into a bath of potassium cyanide for several minutes; finally it is subjected to the action of a bath of ferrous chloride, composed of 500 grammes of hydrochloric acid, 500 grammes of water, and 1 gramme of iron. After each operation the object is washed in clear water.

Good results are obtained from a plating bath composed of water, 1000 cubic centimeters; chloride of nickel, 50 grains; boric acid, 20 grains; with a current of 1 ampere per square decimeter at 2.5 volts. The good results of the process appear to depend upon the perfect cleaning and a suitable deposition on the aluminium of a thin coating of iron from the iron bath.

Under these conditions the nickel deposit infiltrates through the surface of the aluminium and adheres so thoroughly to it that, however heavy the deposit, it is impossible to detach the nickel without removing particles of aluminium.

# Mica*

## Its History, Production and Utilization

AT ONE time the name "Mica" was employed for various minerals which glittered and possessed the property of cleavage, without any sharp distinction being drawn between the several kinds. As the science of mineralogy advanced, however, more and more species came to be distinguished, so that to-day one speaks no longer simply of Mica, but of a Mica group. According to Naumann, this group is comprised of ten species, of which each includes a number of varieties. Hintze gives the following summary of the Mica group:

1. Ferromagnesia mica: Biotite (Meroxene, Anomite, Lepidomelane, *Phlogopite*).
2. Ferrolithia mica: Zinnwaldite (including "Raven-mica," Kryophyllite, and Polylithionite).
3. Alkali-Mica,
   (*a*) Lepidolite: Lithium mica.
   (*b*) Muscovite: Potassium mica.
   (*c*) Paragonite: Sodium mica.
4. Chalk or Lime mica: Margarite.

We cannot here undertake to deal with all the micas, but shall rather concern ourselves only with those which have great technical importance, and are therefore extensively mined. From the earliest times these have been the muscovite, or potassium-mica, and the phlogopite species. The latter is a magnesium mica which, on account of its color, is also called bernstein or amber-mica. Both differ in their geological occurrence, in their chemical composition, and in some degree also in their properties.

It is not surprising that a mineral of such striking characteristics should from earliest time have attracted the attention of mankind. In prehistoric times it was already known to the American Indians, and was employed by them for many purposes.

In India, also, the use of mica was soon discovered, and several mines there have been working for centuries. The mineral was similarly employed in Greece and Rome.

Mica has served as a substitute for glass in other ways. Thus it is recorded by Pliny that the windows of the living rooms, baths, porticos, hot-houses and carrying (Sedan) chairs were of mica. Seneca also mentions "specularia" or window panes probably of mica.

Corresponding with the ancient Roman name of "lapis specularis" was the Greek name τὸ διαφανές "the transparent," which shows that the property of mica of letting light through was noticed by the Greeks to be its special characteristic.

The writers of the middle ages, when discoursing on mica, repeatedly confused this mineral with gypsum, as did Pliny before them. On the other hand, there were several names for mica, as the different varieties were held to be different kinds.

Agricola, one of the earliest of the mediæval mineralogists, writes of lapis specularis, διαφανές, magnetis, ammochrysos, "cat's gold," "cat's silver," "Our Lady's Ice-spar," or simply "ice" (glacies), and also mentions the name *mica*, obviously derived from the Latin "micare," to shimmer or sparkle. This name was later introduced into the French, English, Italian, Spanish, and other languages, and is now the most generally used term.

Wallerius, in 1747, first distinguishes several varieties of mica. He mentions a "variato alba, flava, rubra, viridis, nigra, squamosa, radians, fluctuans, hemisphaerica (white, yellow, red, green, black, muddy, streaky, wavy and hemispherical). The German word "Glimmer" was laid down as the correct German scientific name by Werner, the word being derived from "glimmern," meaning to glitter, and therefore analogous to "mica."

Mica occurs principally in plates without any regular shape, and varying in size from little scales to plates of considerable dimensions. Colles records having seen pieces of three to four feet in diameter, and one of over 7 feet in length. But all earlier records were broken by the finding of a crystal in the Inikurti mine in India which measured 10 feet over the cleavage surface and 15 feet over the leaves.

Most of the plates are irregularly constituted in some way, being either nitched, folded, twisted, or intergrown one in another. A large number contain various impurities, and these imperfections account for the small percentage of mica pieces which are suitable for commercial purposes.

Perfect crystals, that is, crystals which have all their surfaces completely developed, are rare, and particularly good specimens which are suitable for optical experiments, or, on account of their perfect surfaces, are adapted to exact angular measurements, are even exceptional. For this reason, there long existed an uncertainty as to the character of the mica crystal. It often appears to be a six-sided regular prism (Fig. 1), and consequently the mica crystal was classified in the hexagonal system until exact optical measurements by Hintze and Tschermak gave a proof that all micas belong to the monocyclic system, although they may approximate to a hexagonal symmetry.

If a mica crystal is treated with a solution of fluorspar in sulphuric acid, it is attacked by the hydrofluoric acid produced, and on interrupting the action at the correct moment curious figures are found to be etched into the surface. These figures correspond in symmetry with the whole crystal, and important conclusions may be drawn from them. Fig. 5 illustrates such "etch-figures" on a cleavage surface of muscovite. It is readily found that there is only one line which divides the figure symmetrically. The crystal has therefore only one symmetrical plane at right angles to the etched surface, instead of six, as would be the case if it belonged to the hexagonal system—a further proof of its monocyclic character.

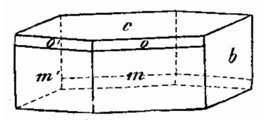



Fig. 1—Single individual. Biotite crystal.

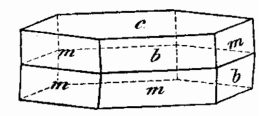



Fig. 2.—Twin biotite crystal, with individual crystals lying one over the other.

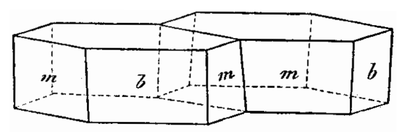



Fig. 3.—Twin biotite crystal with individuals lying side by side.

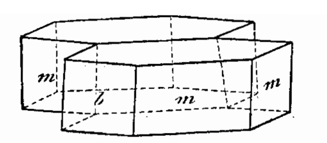



Fig. 4.—Twin biotite crystal with individuals lying side by side.

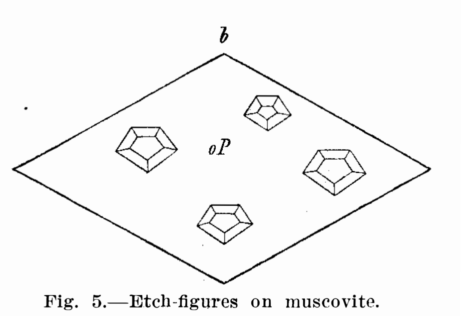



Fig. 5.—Etch-figures on muscovite.
(*All from "Mineralogy," by Naumann and Zirkel.*)

The crystal forms of muscovite and of phlogopite are very familiar, both resembling hexagonal plates or low prisms (Figs. 1-4). Occasionally the crystal has a pyramidal form. The angle between the two surfaces marked *m* in Fig. 2 of the normal mica crystal is 120 degrees 47 seconds, differing thus only slightly from the angle of 120 degrees of the hexagonal crystal, and thus accounting for the apparent hexagonal shape.

Occasionally one meets with twin-formations, that is, crystal forms produced by the intergrowth of two crystals according to fixed laws. Generally the two individuals lie one on top of the other (Fig. 2), but sometimes they lie side by side (Figs. 3-4). The axes of two crystals grown one over the other, as in Fig. 2, are generally at an angle of 120 degrees.

Foreign bodies are very often found embedded in the crystals; for example, in muscovite, scales of feldspar, or, rarer, small crystals of beryl, needles of tourmaline, crystals of quartz, feldspar, garnet or zirkon. In phlogopite, one finds calcite, apatite, feldspar, and quartz. Brown or red layers of iron-oxide occur in both. These impurities can, when they are present to a large degree, render the mica unfit for use, as they are mostly conductors of electricity. They occur generally in the form of dendritic asterisms. Often, they take the form of lines or streaks lying in three directions and cutting each other at 60 degrees, parallel to the percussion lines (see below).

Of particular interest are the cohesive qualities of the mica crystal. Practically all kinds of mica exhibit a pronounced cleavage parallel to the plane *c* in Fig. 1. This is so perfect, more so than in any other mineral, that one can obtain flakes of 0.006 millimeter only in thickness. Mica crystals exhibit cleavage also, but to a smaller degree, in other directions at right angles to *c*.

If a needle is set on a plate of mica and is driven slightly into it by a gentle but sharp blow with a small hammer a remarkable figure is produced consisting of fractures having the form of a six, or sometimes a three-rayed star; this is the so-called percussion figure first observed by Reusch. Of particular importance is the fact that the resultant three lines always run parallel to the edges which the bounding surfaces of the crystal make with the base. This gives a ready means of bringing out the crystal form of completely shapeless pieces of mica.

If the percussion figure experiment is modified, by using a blunt instrument with rounded end instead of a needle, which is merely pressed hard on the mica plate instead of a blow being given, other lines of fracture will be produced which halve the angles of the percussion figure. These are called pressure lines, and the whole the pressure figure. The pressure lines do not exactly follow the regular arrangement of the percussion figure, but generally consist of olny a three-rayed star.

If a clear crystal of Iceland-spar is laid on some printed matter the letters looked at through the crystal appear in duplicate. This is a result of the well-known optical property of calcite called "double refraction." There are many other double refracting minerals, but they do not exhibit this characteristic to such a pronounced degree. Among these is mica. In every crystal exhibiting double refraction there are either one or two directions in which this double refraction does not occur. This direction is called the "optical axis," and one distinguishes between single optical axis crystals and double optical axis crystals. Mica belongs to the latter class. The plane formed by the two axes is called the "axial plane," and this direction is of considerable value in determining the nature of a crystal. There are some micas in which this plane is at right angles to the plane of symmetry, and others in which it is parallel to it. The latter are called "micas of the second order," while the former are known as "micas of the first order." Muscovite is a mica of the first order, phlogopite of the second order. It is, therefore, possible to distinguish between muscovite and phlogopite on a purely optical basis.

The angle enclosed by the two optical axes is known as the axial angle. This angle varies considerably with different kinds of mica, the values appearing to have some relation to the chemical composition. This value is never constant for even the same variety of mica, and Tschermak has found different angles even for different laminæ of the same phlogopite crystal. The angle is also dependent upon the temperature of the crystal.

The axial angle of muscovite varies between 40 degrees and 70 degrees. With phlogopite it is considerably less; Tschermak found values for red light between 0 degree and 17 degrees 25 seconds.

A peculiar optical property exhibited by many pieces of mica is that of asterism. If one holds before a source of light in a dark room a piece of paper which has had a hole made through it with a needle, and looks at this brightly illuminated opening through a suitable piece of mica, one sees at the point of light a more or less regular six-rayed star, the rays of which are at 60 degrees to one another. If the mica sheet is turned about an axis at right angles to its surface, the star is turned round with it, the rays on the plate retaining the same arrangement. A comparison with the percussion figure shows that the rays of the star lie parallel to the percussion lines.

By careful observation a second faint star can be seen between the lines of the brighter star, the rays of which halve its angles. The rays of this second star are, therefore, inclined at 30 degrees to the percussion lines and run parallel with those of the pressure figure. The brighter star is called also the primary or principal star, and its fainter companion the secondary or auxiliary star. The production of this effect has been investigated by several experimenters. The cause of this remarkable effect is doubtless the presence of numerous small inclusions in the mica plate, as in the case of several other minerals, such as certain sapphires and cat's-eyes. Under the microscope innumerable fine lines parallel to the cleavage plane of the crystal can be seen. Most of these lie in three directions at angles of 60 degrees with one another, at right angles to the percussion line, and produce the principal star. A smaller number of needle-shaped structures lie in three directions at right angles to the above inclusions which produce the primary star. These structures are the cause of the secondary star, which is weaker than the principal star because the number of inclusions producing it is smaller (Tschermak).

An optical property not so often observed is that called "pleochroism," that remarkable color effect produced by the unequal absorption of light in the principal directions of doubly refracting crystals. There is no sign

* Abstracts from a work by Hans Zeitler.

of this with ordinary mica sheets, crystals with particularly good development of the principal surfaces being required to exhibit it. Suitable specimens when looked at in the direction of the cleavage plane show a different color from that appearing in the direction at right angles to it, and the color in the latter case is usually brighter.

The differences in color are rarely perceptible with the unaided eye, but generally require for their observation the use of a specially constructed instrument called the "dichroscope."

The hardness of a mineral is determined by attempting to scratch other minerals with pointed pieces of the mineral in question. In order to develop a universal scale of hardness, Mohs established a series of ten minerals representing different degrees of hardness. The second degree of hardness is represented by gypsum crystals, the third degree by carbonate of lime crystals. The hardness of mica is between these two degrees, as it scratches gypsum and can be scratched by carbonate of lime.

Although the different kinds of mica have practically the same degree of hardness in a mineralogical sense, yet more defined differences in hardness are made in the mica industry, as the hardness of any particular kind often determines its suitability for a particular purpose. The following grades are principally recognized, the first being the softest:

1. Amber mica.
2. White India mica.
3. Soft green Madras and Calcutta mica.
4. Ruby India mica.
5. Hard green and brown Madras.
6. Green, brown and yellow East Africa mica.
7. Green United States mica.

In the case of the amber mica there is a further commercial distinction between three principal kinds:

1. Clear, transparent soft amber mica.
2. Streaked amber of medium hardness.
3. Opaque hard amber.

The determination of the specific gravity of the different kinds of mica is beset with special difficulties. Between the fine laminæ of which every piece of mica is composed there is always more or less air which it is hardly possible to eliminate. Attempting to powder the mica is not of much use, as, on account of its structure and slight brittleness, it is not suited to this method. According to Naumann, the specific gravity of phlogopite varies between 2.75 and 2.97; that of muscovite between 2.76 and 3.1. Mica has about the same specific gravity as limestone, marble or aluminium.

On the question of the elasticity of mica, one finds in different books exactly opposite views. Measurements carried out on muscovite plates by Coromilas showed that only very small differences in elasticity exist along different directions within the cleavage plane. The maximum deviation due to the effect of a definite load was obtained parallel to the axis of symmetry, the minimum deviation at an angle of 45 degrees to that axis. The modulus of elasticity is (according to the tables of Landolt-Börnstein), 22,133 in the direction parallel to the axis of symmetry, and 15,543 in the direction 45 degrees to this axis.

Of particular interest is the conduct of mica under electrical strain. Its dielectric constant varies with the duration of the charge. Immediately after the application of the charge the conductivity at ordinary temperatures is quite appreciable. According to Liebisch the dielectric constant has for the first fraction of a second a value about 4.6. H. W. Schultze found that the conductivity increased with temperature until it reached a maximum value, sinking again to a remarkably small value at very high temperatures. In the following table giving results by J. Curie, the specific conductivity in C.G.S. units is denoted by $c$, and the temperature by $t$.

| *Duration of charge.* | 10 seconds. | 1 minute | 10 minutes. | 60 minutes. |
|---|---|---|---|---|
| $t$ = 20° C. | $c$=0 000457 | $c$=0·000103 | $c$=0 000015 | $c$=0·000003 |
| $t$ =100° C. | $c$=0·001030 | $c$=0·000257 | 0·000066 | — |

The dielectric strength or resistance to high electric pressure has been carefully investigated by many, including Steinmetz. In comparison with that of other bad conductors it is remarkably high, for which reason mica is an insulator of the highest value. Steinmetz found that the following values for the disruptive strength at 5,000 volts, the figures being obtained by division of the disruptive pressure by the thickness of the material in millimeters.

| Material. | Breakdown voltage per mm. |
|---|---|
| Air ... ... ... ... ... ... | 1,670 |
| Mica ... ... ... ... ... | 320,000 |
| Dried wood fibre ... ... ... ... | 13,000 |
| Paraffin paper ... ... ... ... | 33,900 |
| Melted paraffin (65° C.) ... ... ... | 8,100 |
| Turpentine ... ... ... ... | 6,400 |
| Copal varnish ... ... ... ... | 3,000 |
| Vulcabeston ... ... ... ... | 3,600 |
| Asbestos paper ... ... ... ... | 4,300 |

It will be seen that mica has by far the highest disruptive strength of all the materials mentioned.

The surface conductivity of mica is not inappreciable. Quantitative figures cannot be given, as exact measurements are not available. As mica is a poor conductor of electricity it becomes electrified by friction. The character of the charge depends on the kind of rubbing material, and also on many circumstances, such as the nature of the surface. According to these it is sometimes negative and sometimes positive. An electrical charge is also produced when mica plates are rubbed against one another. When laminæ of sheets are separated, one cleavage surface is positive, the other negative. If a thin sheet of mica is torn sharply through in a completely dark room a greenish light appears at the torn edge, the light being stronger when a sheet made up of several laminæ is torn.

Besides the disruptive strength, resistance to heat is an important characteristic of any insulator, and, in this respect also, mica possesses high qualities. Experiments in a furnace with means for measuring temperature gave melting points between 1,200 deg. Cent. and 1,300 deg. Cent., according to the kind of mica.

Bad conductors of electricity are nearly always bad conductors of heat, and mica follows this rule. With regard to the transparency of mica for heat rays, we have been unable to find statements based on measurements. As such information has, however, considerable practical value, we have ourselves made experiments with a differential thermoscope, which, although not suitable for exact physical measurements, gave results which are suitable for a general discussion. The transparency of mica was compared with that of window-glass of 1.66 millimeter in thickness. Taking the transparency of the latter at 100, the value obtained for most of the mica plates investigated was about 60; in other words, the transparency of mica to heat rays compared with that of the glass plate in the proportion of 6 to 10.

By the expression specific heat is understood the quantity of heat which must be added to one kilogramme of a body in order to raise its temperature by one degree centigrade. Of all materials, water has the highest specific heat. If the specific heat of water is denoted by one, mica, according to Ulrich, has the following values:

Alkali mica, 0.2080.
Magnesium mica, 0.2061.
Sodium mica, 0.2085.

Micas are, from a chemical point of view, silicates of alumina and alkalies, in many cases also combined with magnesia and iron oxide. Among those kinds with which we are concerned, biotite is distinguished by its high content of magnesia (from 10 per cent to 30 per per cent), and by its often considerable content of iron from muscovite, which is, on the other hand, richer in alumina and silicic acid. Both micas practically always contain some water, which is only eliminated by continuous heating at a high temperature. The maximum water content is about 7 per cent for muscovite, about 15 per cent for biotite, and considerably less for most other varieties. Fluorspar is present in both micas, more so in muscovite (about 4.15 per cent) than in biotite. When present with water it disappears on the mica being brought to a glowing heat. Iron can be quite absent in both micas. The maximum found in muscovite has been 8.8 per cent, but considerably more has been found in biotite. Besides the normal constitutents, many subsidiary impurities occur, and these are collected together under one heading in our tables. Sodium occurs occasionally together with potassium, at times also lithium, together with silicic acid, titanic acid, also chromium oxide, together with alumina and iron oxide. Biotite occasionally contains also rubidium, manganese, barium, calcium, and also traces of cobalt and nickel. The determination of the composition of mica is beset with no small difficulties. The different kinds are often completely intergrown one with another, or the crystals contain inclusions of different kinds, so that it is very difficult to obtain a pure and homogeneous mass for the investigation. It should further be noticed that many micas undergo a gradual transformation into other minerals. If such a piece is analyzed, incorrect results will be obtained, as the original mica is now mixed with the mineral into which it has changed. For research purposes, therefore, freshly mined crystals must be employed. Not only the material, therefore, but also the analysis, has its pitfalls. On account of the presence of fluorspar certain treatments are rendered more difficult. Again, the lower oxide of iron must be determined separately from the higher oxide. Even the determination of the water content offers particular difficulties.

Chemical action generally prepares the way for mechanical destruction. If water, for example, penetrates between the laminæ of a crystal, the cleavage surfaces are opened out, especially if frost has set in. The crystals finally split up into numerous small scales, and the exposed surface is enormously increased. If iron oxide is present it is converted to hydroxide and the mineral assumes gradually a color, and sometimes at this stage has a metallic or golden appearance. If water containing carbon-dioxide is present, the mica eventually decomposes into alkaline substances. If manganese oxide is present this also is changed into hydroxide.

It is more of theoretical than practical interest that it has already been possible to produce mica artificially.

With the exception of quartz and Iceland-spar, there is hardly any other crystalline mineral which is so widely distributed in the various layers of the earth's crust as mica. In the composition of many rocks spread over the whole world, mica plays a most important part, and also accounts for the stratified structure of the rock in cases where the scales of mica lie parallel.

In crystalline rock potassium mica occurs particularly in conjunction with a feldspar rich in silicic acid, especially with orthoclase, while biotite occurs often with oligoclase and hornblende, taking the place of the latter in many cases. Biotite, as well as muscovite, is present in the most important mica rocks, such as granite, gneiss, and mica schists. Biotite is also a more or less important constituent of many other stones, as, for example, of granulite, the stratified structure of which is increased by its presence, in amphibolite, gabbro, norite, melaphyre, in many basalts, porphyries, in trachyte, phonolite, and elæolite syenite.

If these rocks are disintegrated and built up again, new kinds of rock are produced, known as clastic sedimentary rocks. Only potassium mica appears in these, as the easily decomposed biotite disappears during the change. We thus come across muscovite in sand, sandstone, graywacke, and breccia. Finally, mica (biotite) is present in volcanic products.

The above mentioned may be termed "primary micas," while those micas produced by the transformation of other minerals may be termed "secondary micas." As this change extends in nature over a long period, one often finds specimens in which the various stages of the transformation can be followed. The original mineral, when of crystalline character, occasionally also retains its outer form, and the new mineral produced appears in a pseudomorphous form. Thus, for example, corundum can change into muscovite. The monoclinic mica then compares with the rhombohedral form of corundum, although it does not correctly belong to it.

Secondary muscovites can result from the following minerals: disthene, tourmaline, fibrolite; from corundum, either direct or with disthene and fibrolite as intermediate steps; from andalusite, cordiolite, nepheline, topaz, zoisite, elæolite, garnet, scapolite, and potash feldspar. Secondary biotites are produced from hornblende, tourmaline, augite, fassaïte, and from corundum with chlorite as intermediate.

While mica is found almost universally, the occurrence of deposits which yield sheets of commercial value is rare. As a source of mica, India takes the first place and yields more than all the other countries of the world together. Canada and the United States come second, with approximately equal production. German East Africa comes a poor third, but, nevertheless, exports more than all the remaining countries together. The latter include Brazil, Argentine, Norway, Siberia, South Africa, Japan, and China. The mica obtained from most of the above sources is potassium mica. Phlogopite deposits of commercial importance are found only in Canada and Ceylon.

Mica extraction is a special branch of the mining industry. It is not purely a matter of extracting masses of material, as in the case of ore mining where the production of a great mass of material is the great aim, and where it is quite immaterial whether the ore is obtained in large or small pieces. Mica extraction cannot either be directly compared with quarrying, as building stones, slate, and gypsum occur generally in compact masses, wholly suitable for extraction, whereas mica plates are more or less distributed in the rock. It is always necessary to extract the intermediate rock in order to reach further deposits of mica, a circumstance which naturally much increases the cost of mica extraction. In North Carolina, for example, it is necessary on an average to extract one ton of rock in order to produce 200 grammes of commercial mica. Further, while the value of ore, salt, or coal deposits can be predetermined with a great degree of accuracy, it is never certain in mining for mica whether the yield will pay for the construction of the pits and galleries.

In Canada the dressing is carried out as follows: After blasting, the mica blocks are separated from the pieces of rock and undergo a process of selection. Those which appear to be of value are shaped by cleaving, and the others are thrown away. The shaped plates are then cleaned and sorted. A further dressing is given in the mica cutting works.

Of the total amount of mica extracted from the mine only from 2 per cent to 5 per cent is actually used commercially. All the rest is wasted. Within recent years, scales of mica which are too small for direct commercial application are employed in the manufacture of micanite, mica mats, and mica powder.

The manufacture of compressed micanite for com-

mutators is carried out in the following manner: the finely split mica scales are laid out over a large table in such a manner that they just overlap, a strongly insulating binding material is spread over it, and then a second layer is laid out in such a manner that the joints in the lower layer are covered by whole pieces. Several layers are made up in this way until a plate of the required thickness is produced. The plate is then put into a large steam-heated hydraulic press, and subjected to a very great pressure.

In the process for the manufacture of mica mats the mica waste is passed through ribbed rollers in order to loosen the scales which are then separated by means of a powerful air blast. The scales are then arranged in layers of suitable thickness, and passed between lightly galvanized wire netting, to which they are sewn with wire by means of a special machine. In this manner a flexible web of mica is produced, and this is covered on one side with stiff linen, and on the other with paper, and finished off to the desired shape.

In the manufacture of mica powder considerable difficulty is experienced on account of the properties of the mineral. Thus, it is not possible to pulverize mica in the ordinary manner, as sufficient friction cannot be produced either between the slippery scales themselves or between the scales and the grinding stone. This difficulty, however, was overcome by the construction of special machinery.

While mica is only employed in large quantities for a very few purposes, its applications are remarkably varied, and it is of considerable interest to discuss some of these applications which, while of no commercial importance, may be of interest for other reasons.

By far the largest quantity of mica is at the present time employed for insulation purposes in the electrical fndustry. Pure mica has, however, recently been largely superseded in heavy electrical work by an artificial mica or micanite. It has also the advantage that it can be made up into any desired shape and is free from certain iaults which often occur in natural plates.

Mica is employed also as an insulating material for all kinds of electrical apparatus; for example, for the insulation of terminals from their bases, in thermocells, for the support of the wires in bolometers, for resistances, and for the insulation of induction coils. It is also used as an insulating medium between the plates of condensers.

As already pointed out, the specific gravity of mica is by no means small. It is possible, however, owing to the extraordinary cleavage properties of the mineral, to obtain scales of very minute weight, which are at the same time comparatively strong and are not easily broken. As a consequence of this, strips of mica are employed in the manufacture of many scientific instruments.

The use of a thin mica sheet for compass cards is a comparatively early application.

The resistance of mica to the effects of high temperatures, and its capability of withstanding rapid changes of temperature, make it a suitable substitute for glass, in cases where the latter would easily crack.

Its high opaqueness to heat rays makes mica particularly suitable for other purposes. Thus, the condensing lens of projection apparatus is subject to severe heat from the source of light, which may result in the destruction of the lens, and so it is usual to protect it by an intermediate plate of mica, or a vessel of water.

In India cheap mica waste is employed as a protection against the intense radiant heat of the tropical sun, for stuffing helmets, portions of clothing, vehicle hoods, etc.

The heat conductivity of mica is also very low. It is employed, therefore, where it can be obtained cheaply, for the insulation of ice machines and ice chambers, and particularly for steam boilers and steam pipes, partly in the form of powder and partly in the form of mica mats.

Mica is also employed as a lubricant for axles under great pressure.

Mica waste is in large demand in some districts of India. On certain festive occasions, banners, sunshades, clothes, fans, toys and vases are sprinkled with it on account of the glittering effect produced in sunlight.

As in the case of many natural products which exhibit peculiar properties, mica is also employed among some peoples for medical purposes, not only in India but in China.

On account of the ease with which mica plates are split into thin laminæ and cut with scissors, and their comparative strength, they are particularly suitable for cover "glasses" for microscope slides. The use of mica for this purpose has been found particularly convenient in the case of series of sections. Plates of mica for holding zoological preparations which are to be preserved in spirit are prepared in the same way. These plates have this great advantage over glass, that they can be pierced with a needle in order to fix the preparation to them.

As mica is practically unbreakable, it is used for making photographic plates and films for explorers. Mirrors have also been made of mica, and silvered plates which can be bent into different forms have been used as reflectors. Mica window panes are still employed in many places even to-day.

Mica is absolutely indispensable for many crystallographic experiments with the polarization microscope. For this purpose very fine laminæ, called quarter-wave plates, which have an exact and definite thickness, are employed. These serve to distinguish between monoaxial and bi-axial crystals, as well as to determine the character of chromatic polarization and the properties of doubly refracting bi-axial crystals.

Finally, the elasticity of mica makes it particularly suitable for the reception of sound waves. When one speaks into a gramophone the sound waves pass through a connecting tube into the sounding box. This is a flat cylindrical case open on the side connecting with the trumpet, and closed on the opposite side by a diaphragm of mica or glass.

Mica disks are also employed in the gas-flame manometer, the instrument usually employed for any acoustic investigations.

Mica has been successfully employed in Madras, in the manufacture of artificial stones, this being effected by the compression of mica waste with some binding agent. A kind of dynamite is manufactured by saturating mica powder with nitro-glycerine.

Mica is also employed with good results as an artificial manure. As, however, mica is not at all easily disintegrated, the action can only be a mechanical one, consisting possibly of loosening of the soil.

# The Blind Spot*

## A Peculiarity of the Eye That Is a Source of Danger

By Edna B. Dayton, M. D.

THE blind spot of the human eye has been found to be of considerable importance in regard to driving rapidly moving vehicles. A trained observer has studied and tested the function of the normal eye and its aid to the driver in avoiding collisions. The results of the tests made seem to show a possibility of collision without the driver seeing that a collision is imminent.

Before giving the details of one illustrative test, the facts should be stated that about fifty tests have been made in regard to the effect upon sight of the blind spot, and about thirty people have been used in the tests. This number offers a fairly reasonable proof of the value of the following facts. Also, that for the benefit of those not familiar with the blind spot of the eye and the fovea centralis (area of most perfect sight), a short description of the eye and the physiology of its function is given first as follows:

The eye contains a sensitive surface (the retina) like the film of a camera which takes the impression of the picture that we see. The picture is constantly changing as we turn our eyes and see one object after another. All of the surface of this sensitive part of the eye has this function of perception except one very small spot called the blind spot. This surface also has a small spot of most perfect sight called the fovea centralis. Over the rest of the surface the perfectness of the sight varies, being the least the greater the distance from the fovea centralis.

Starling[1] states that "The point of entry of the optic nerve, where the whole thickness of the retina is composed of nerve fibers, is absolutely insensitive to sight and constitutes the blind spot. If the light of a small flame be directed, by means of a small mirror, into the eye so that it falls only on the optic disk, the individual receives no sensation of light. . . . The blind spot is so large that at the distance of about six feet the image of the head of a man will fall on it and therefore be invisible . . .

"If we fix our attention on an object, we direct our eyes so that the image of the center of the object falls exactly on the fovea centralis of the retina. The diameter of the central spot is about 1 to 1.5 millimeters which corresponds to the visual angle of 4 to 6 degrees. This angle, therefore, represents the extent of the visual field in which we have distinct vision. The light which falls into the eye forms an image of external objects which extends over the whole of the retina. The sensations excited by the stimulation of the periphery of the retina are much more indistinct than those excited by the image on the central spot. The appreciation of external objects, by means of the image they throw on the external parts of the retina, is spoken of as indirect vision in contradistinction to direct vision, which implies fixation of the object and the formation of an image of it on the fovea centralis. The whole extent of the objects which we see by direct and indirect vision is spoken of as the visual field."

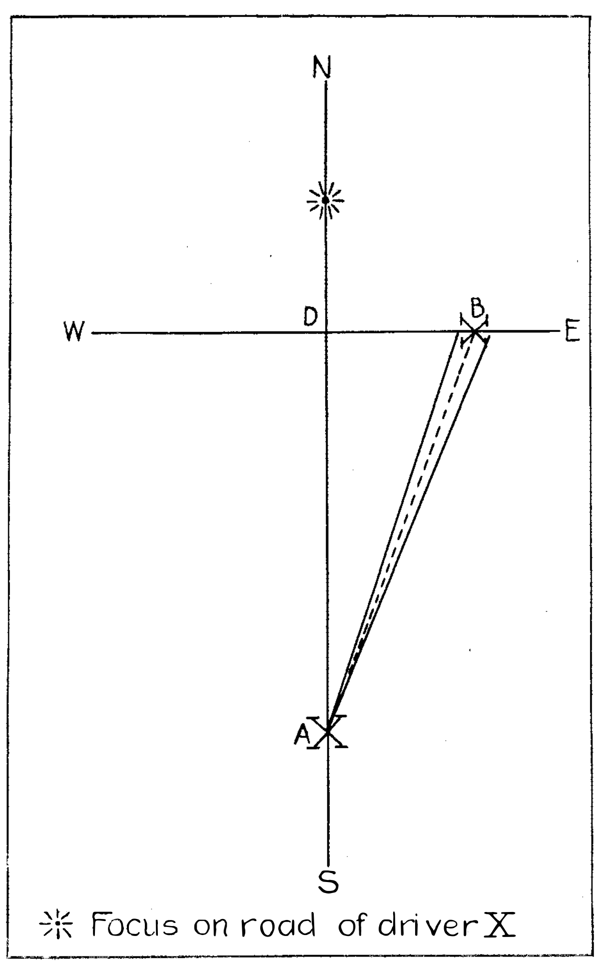



Fig. 1.

Howell[2] helps our understanding of the function of the eye still further when we read: "The termination of the optic nerve within the eyeball, the optic disk, lies about 15 degrees to the nasal side of the fovea centralis and has a diameter of about 1.5 millimeters. From this point the nerve fibers spread out over the rest of the optic cup to form the internal layer of the retina. But the optic disk itself has no retinal structure and light that falls upon it is not perceived. The presence of this blind spot in our visual field is easily demonstrated. . . . In the visual field for each eye, therefore, there is a gap representing the projection of the area of the optic disk to the exterior, the size of the gap increasing with the distance from the eye. We do not notice this deficiency, inasmuch as it exists in our indirect field of vision, . . . in which our perception of form is poorly developed; so that any disturbance in outline that might result in the retinal image of external objects is unperceived. Moreover, the portion of the external world that falls on the blind spot of one eye falls on the retinal field of the other, and is thus perceived. . . . It is to be born in mind, also, that the projection of the blind spot does not appear in the visual field as a dark area; it is simply an absent area, so that no gap exists in our consciousness of the spatial relations of the visual field; the margins, so to speak, of the hole come into contact so far as our consciousness is concerned."

In summing up these statements, we find:



[1] Starling: "Principles of Human Physiology." Edition 1912, p. 626.

[2] Howell: "A Text-Book of Physiology." 5th Edition, p. 330.

1. Rays of light from an object falling upon the optic disk (blind spot) produce no perception of the object.

2. Rays of light from an object falling simultaneously upon the other eye do not fall upon the blind spot, but upon an area of very indistinct perception of the retina external to the fovea centralis.

3. The untrained individual is unconscious of the gap.

Therefore, from 1 we realize that at a certain place on the right and left, the automobile driver sees as with only one eye.

From 2 we realize that the driver sees very imperfectly with the one eye.

From 3 we realize that not knowing his lack, he cannot take measures to reinforce or correct his perceptions.

If the driver notices that an object has not been observed he attributes it to his inattention.

With these facts in mind, a test was made with an automobile. The driver, as is usual on a "straightaway drive," focused the eyes upon the road some distance ahead of the automobile, and held the eyes at rest, depending upon the area of the visual field outside of the fovea centralis to warn him of the approach of vehicles. This circumstance brought out the following problem, which showed itself to be merely one of many such problems:

In the drawing the automobiles of the test are shown to approach at right angles to one another. The drawing shows them diagrammatically illustrated as tried in the test. If automobile *X* traveled north at a greater uniform velocity than automobile *X'* traveled west, they would tend to reach the crossing at the same time or nearly the same time, depending upon the velocity of automobile *X'*. With a certain relation between their velocities, there would be an interval when the driver *X* would not notice driver *X'* because *X'* would be covered by the blind spot. At another certain relation between their velocities *X'* would remain covered by the blind spot in the eye of *X* for a longer interval as they both approached the crossing.

An automobile, because of its weight and consequent momentum at different velocities, has to allow a certain distance in which to stop. A circular area a little less than this distance surrounding the place of crossing has been named the danger zone. By this is meant, that as soon as the automobile enters the zone it is very difficult to stop or turn quickly enough to avoid a collision.

Referring again to the drawing, the possibility of two automobiles, moving rapidly, but at different velocities, coming into the danger zone without realizing their proximity, is easily seen. If the reader will, cut a piece of paper to fit the triangle *DAB*, apply the edge *DA* of the cut paper to the line *DA*, and move the paper north along the line, he will readily see how the rays of light coming from *X'* may continue to fall on the blind spot of driver *X* provided *X'* travels at a certain velocity.

Now if the cut paper is applied to the line *DB* by turning the paper over, so that point *A* comes on *B* and the edge *DA* and *DB*, the reader will see that while automobile *X* is not covered by the blind spot of driver *X'*, the rays from *X* do fall so far out on the area of indistinct vision of *X'* that *X'* is not aware of approaching *X*.

In this way both automobiles may enter the danger zone and meet in collision, without either driver being responsible. This possibility was actually seen to happen by the writer who was in one of the automobiles. It led to the test stated above. A remarkably quick skillful driver of one of the automobiles avoided a collision by about an inch.

The problems arising out of this combination are many, depending upon the angle formed by the direction of the approaching automobiles, the relative velocity, or acceleration of the two automobiles, and the point of focus of the drivers. These combinations are being studied in detail along with the other factors involved by the condition.

As soon as we accept this proof, the question immediately arises: What is to be done, since the defect is a condition of the eye normally existing in every individual and will not be removed by glasses?

One solution is that of keeping the eyes constantly in motion, but that is very fatiguing, especially when there are many objects, and the road is imperfect, or unfamiliar. There is also the possibility of an automobile rounding a sharp curve and colliding while the eyes of the other driver are momentarily turned aside.

Another solution presents itself, which is that of training. Each automobile establishment could easily supply itself with the simple apparatus necessary for the test. Then each automobile buyer by a few lessons would become conscious of the area covered by the blind spot and learn the angle at which an object comes into the area of no vision. In this way, the driver could protect himself by a relatively slight movement of the eyes covering those angles, especially when approaching a crossing.

When a driver realizes that traveling at twenty-five to thirty-five miles an hour he covers a distance of only fifty feet in a moment, and at that distance at a certain angle on the side there is an area six feet high by four feet eight inches at its widest part, over which area he has no sight in one eye, he readily understands the cause of many accidents. He quickly feels the need of an understanding of the condition.

NOTES ON TESTS FOR THE BLIND SPOT.

Four tests were made for each individual, and the method of arrangement for the tests is shown by the accompanying illustration, Fig. 2.

The tests are given briefly as follows:

Test 1. The eyes of *EE'* were focused on point *, then the right eye was covered.

A black ball was passed slowly along imaginary horizontal lines on the white surface of the bristol board *BC*, then along vertical lines marking the points where the ball was lost to view and where it again came into view. These points were marked and connected by black lines. Thus approximately outlining the area on the surface of the bristol board from which rays of light passing to the retina produced no sensation of sight.

Test 2. A red disk of the same diameter as the black ball was substituted and passed over the surface of the same bristol board. The points were marked as in Test I, but with red, and connected with red lines.

Tests 3 and 4. Green and then blue disks were used in succession with the points and connecting lines marked in corresponding colors.

After a number of individuals had been tested the record outlines were compared. The results showed that the four outlined areas varied in size and shape for each individual, but that there was a certain degree of individual uniformity in contour and size of the four areas for each individual examined; however, the centers of these areas were not the same either for the four tests of one individual or for the same test in different individuals.

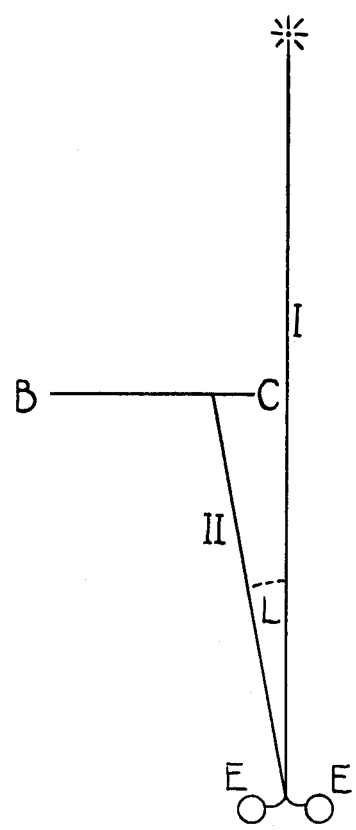



**Fig. 2.**

While making the four tests described an effort was made to determine the size of the angle *L* made by the rays of light coming from the area outlined and a ray of light coming from the point upon which the eyes were focused. For this purpose an arbitrary arrangement of apparatus was made. A fine wire was fastened at point * and drawn taut to a point midway between the eyes *EE'* by a bar small enough not to interfere with the sight of either eye. From this bar the second wire *II* was drawn to a point in the black outlined area of each individual on the bristol board nearest edge *C*. The angle *L* was found to vary in degree for different individuals, but only an occasional individual showed marked variation. The angle *L* of the automobile driver in Fig. 1 was approximately 12 degrees.

For the automobilist the small angle *L* brings the possibility of collision in the cases shown in Fig. 1. Automobile *X* is moving rapidly while *X'* is moving leisurely on an intersecting road, moving out of a driveway, or where a child attempts to cross a street just at the moment when *X* approaches rapidly and turns the corner.

These tests show that while an individual may be given an approximate idea of the position and size of the area covered by the blind spot at various distances, those individuals driving rapidly moving vehicles and depending upon signals for safety should be sufficiently practised to know definitely the size and position of their projected blind spot area.

## Coal Fields of the United States

THE coal areas of the United States are divided, for the sake of convenience, into two great divisions—anthracite and bituminous.

The areas in which anthracite is produced are confined almost exclusively to the eastern part of Pennsylvania, and usually when the anthracite fields of the United States are referred to those of eastern Pennsylvania are meant. These fields are included in the counties of Susquehanna, Lackawanna, Luzerne, Carbon, Schuylkill, Columbia, Northumberland, Dauphin, and Sullivan, and underlie an area of about 480 square miles. In addition to these well known anthracite fields of Pennsylvania there are two small areas in the Rocky Mountain region where the coal has been locally anthracited, although the production from these districts has never amounted to as much as 100,000 tons in any one year. One of these localities is in Gunnison County, Colo., and the other in Santa Fé County, N. Mex. The coal, although only locally metamorphosed, is a true anthracite and of a good quality. In previous years some coal which was classed as anthracite was mined and sold in New England. The productive area was confined to the eastern part of Rhode Island and the counties of Bristol and Plymouth in Massachusetts.

The bituminous and lignite fields are scattered widely over the United States and include an area of more than 450,000 square miles. The previous classification of these coal areas published in earlier volumes of the report Mineral Resources of the United States has been changed as a result of conferences among the geologists working under Marius R. Campbell on the economic geology of coal. The areas are divided, primarily, into six provinces, as follows:

(1) The eastern province, which includes all of the bituminous areas of the Appalachian region; the Atlantic coast region, which includes the Triassic fields near Richmond and the Deep River and Dan River fields of North Carolina, and also the anthracite region of Pennsylvania. (2) The Gulf province, which includes the lignite fields of Alabama, Mississippi, Louisiana, Arkansas, and Texas. (3) The interior province, which includes all the bituminous areas of the Mississippi Valley region and the coal fields of Michigan. This province is subdivided into the eastern region, which embraces the coal fields of Illinois, Indiana, and western Kentucky; the western region, which includes the fields of Iowa, Missouri, Nebraska, Kansas, Arkansas, and Oklahoma; and the southwestern region, which includes the coal fields of Texas. The Michigan fields are designated as the northern region of the interior province. (4) The northern or Great Plains province, which includes the lignite areas of North Dakota and South Dakota, and the bituminous and subbituminous areas of northeastern Wyoming and of northern and eastern Montana. (5) The Rocky Mountain province, which includes the coal fields of the portions of Montana and Wyoming which are in the mountainous districts of those States, and all the coal fields of Utah, Colorado, and New Mexico. (6) The Pacific coast province, which includes all of the coal fields of California, Oregon, and Washington.—*From a report by the United States Geological Survey.*

## Alloy of Nickel and Tantalum

THE resistance of nickel to acids is considerably increased by an addition of tantalum. Ordinarily from 5 to 10 per cent may be added, but the resistance increases with an increasing percentage of tantalum. An alloy of nickel with 30 per cent of tantalum, for example, can be boiled in aqua regia or any other acid without being affected. The alloy is claimed to be tough, easily rolled, capable of being hammered, or drawn into wire. The nickel loses its magnetic quality when alloyed with tantalum. The alloy can be heated in the open air at a high temperature without oxidizing. The method of producing the alloy consists in mixing the two metals in a powdered form, compressing them at high pressure, and bringing to a high heat in a crucible or quartz tube in a vacuum. For general purposes, the alloy is too expensive.—*Machinery.*

## Germany Produces An Oil Substitute

SHORTAGE of the ordinary lubricating oil used on railways in Germany has compelled a search for substitutes, and has resulted in the development of a series of lubricants from coal tar oils. They are produced in various grades of viscosity, and are said to be extremely cheap.

## Notes on the Eucalyptus Oil Industry of California*

**By P. W. Tompkins**

*Eucalyptus globulus* oil produced in California has been characterized, since the Pure Food and Drug Act, by its non-conformity to the U. S. P. solubility standard in three volumes of 70 per cent alcohol by volume, a guarantee now required by wholesale druggists. While this difficulty can be readily overcome by appropriate fractionating, it is at the expense of a certain portion of the oil and a cost not favorably comparable with Australian conditions of production, with which we must compete.

A feature developed during an investigation of the industry begun in 1912 satisfactorily explains the wide variation occasionally encountered in California oils. A considerable proportion of the trees cut are topped or stumped and the subsequent growth develops a very prolific and dense foliage. Since this new wood is sometimes recut, its influence on the oil derived exclusively from mature trees was determined.

Two sections were found where the new foliage (all globulus) was fairly accurately established as being five years old and was from topped trees while the other was a lot of one year sucker shoots from tree stumps. Each batch of 400 pounds (with a minimum of terminal twigs) was separately distilled and is compared with an oil from trees about thirty years old, with salient characteristics briefly determined as follows:

OILS FROM EUCALYPTUS GLOBULUS, ALL FROM SAN FRANCISCO COMPANY.

| | 1 Year. | 5 Years. | 30 Years. |
|---|---|---|---|
| Yield, per cent | 0.09 | 0.21 | 0.84 |
| Sp. gr. —25 deg. | 0.890 | 0.906 | 0.908 |
| Sol. 70% alcohol by weight | 15 vols. | 3.25 vols. | 1.5 vols. |
| Sol. 70 % alcohol by vol. | Insoluble | 45 vols. | 15 vols. |

Obviously the young growth furnishes much less oil in proportion to its age, and its inferior quality would have an undesirable influence on any run. Aside from a very marked difference due to locality, observed in oil from mature trees, this young growth would apparently account for the abnormal character of California oils noted from time to time. What age the new growth must attain before its oil fully matures, would be an interesting subject for those having the opportunity to investigate.

However, the greatest difficulty the California industry has to contend with, aside from the decreased oil recovered, in order to bring its product up to present U. S. P. solubility, lies in the fact (practically speaking) that *Eucalyptus globulus* is the only species available in quantities for oil production at the present time, whereas in Australia more productive species requiring no treatment are almost exclusively worked for export. This subject is best illuminated by quoting some correspondence with Richard T. Baker[1] in part as follows:

"There is, however, an erroneous opinion commercially as to the percentage content of cineol in the oil of *E. globulus* and we have species growing naturally in Australia, the oils of which are much richer in cineol than that species, and also yield a much greater quantity of oil. These oils are now largely exported from Australia, particularly that of *E. polybractea*, and are without doubt often sold as the oil of *E. globulus*, as indicated by the records of their sale. In fact, there is at the present time very little oil of *E. globulus* distilled in Australia, as it cannot compete against the more prolific oil-yielding species which are richer in cineol.

"It is not usual to fractionate the oil of *Eucalyptus globulus* and the other rich eucalyptol oils so as to remove terpenes and thus endeavor to increase the eucalyptol content, as this is unnecessary with these species. Rectification by steam distillation is all that is necessary. There are species, however, the oil of which can be much improved by fractional distillation, and the oil of the New South Wales form of *Eucalyptus amydgalina* can be, and is so increased in eucalyptol, by separating the large fraction boiling at about the temperature of eucalyptol; the other portions of the oil are then used for industrial purposes other than pharmaceutical. As a rule, fractional distillation, on a large scale, is not practised to any great extent in Australia in preparing eucalyptus oils for market."

In addition to this unequal basis of competition they now employ, in Australia, digesters of much greater capacity than are used here, some of these taking over three to four tons of green leaves to the charge. A most interesting feature was developed in the fact that the raw globulus oil from Australia does not conform to U. S. P. solubility, unless fractionally distilled like our own, though with less loss. Notwithstanding the popular idea that the raw Australian globulus oil is soluble in three volumes of 70 per cent alcohol by volume, it is in reality not so.

Through the kind assistance of Mr. Baker this valuable comparison was made possible and in submitting the first sample (broken in transit) Mr. Baker stated in part:

"After considerable difficulty I have at last been able to obtain a sample of the oil of *Eucalyptus globulus* which has been forwarded," etc. "The oil was without doubt distilled from *Eucalyptus globulus* and is typical of the oil of this species as grown in Tasmania."

The second sample also from the island of Tasmania was received with the comment:

"I have after considerable trouble secured another sample of *Eucalyptus globulus* oil," etc.

Compared with the average raw California globulus oils from San Francisco County, and normal extremes observed from properly distilled leaves (mature) of several localities, the Australian sample gave the following, compared with Baker and Smith's observations of the New South Wales growth:

| Various Samples of Oils | California (mature growth) Extremes observed. | Average S.F. Co. | Australia (Tasmania) Our Sample | (N.S.W.) Baker & Smith |
|---|---|---|---|---|
| Sp. gr. —25 deg. | 0.901 to 0.909 | 0.906 | 0.9123 | 0.913 |
| Rotation [α] $\frac{25}{D}$ (a) | +11.4 to +7.0 | +8.0 | +3.9 | +9.2 |
| Sol. 70% alc. by wt. | 1.7 to 1.4 vols. | 1.5 | 1.2 | 1.5 |
| Sol. 70% alc. by vol. | 35 to 13 vols. | 15 | 8 | ? |
| Per cent cineol (U. S. P. Method) | 47 to 54 | 52 | 54 | About 50 |
| Phellandrene test | Negative | Neg. | Neg. | Neg. |

(a) Burke and Scalione, *The Journal of Industrial and Engineering Chemistry*, vol. vii. (1915), 206, found [α] $\frac{20}{D}$ + 14.4 from trees at Berkeley, Cal.

Inasmuch as most oils from Australia are soluble in 1.8 to 2.2 volumes of 70 per cent alcohol by volume, it would lead to the conclusion, particularly in view of Mr. Baker's statement and our examination of the Tasmania globulus oil, that this species is not represented in the products received here. Merely in support of its scant production is the fact that of some ten commercial varieties of eucalyptus oil representing the Australian exhibit at the P. P. I. E., *Eucalyptus globulus* is the species conspicuously absent.

It could hardly be considered guess work to assume that the raw globulus oil of Australia is in reality as variable in 70 per cent alcohol by volume as our own, when we compare the constants of the Tasmania sample and those found by Baker and Smith, with over twice the specific rotation and 0.3 cubic centimeter less soluble in 70 per cent alcohol by weight, a very great factor of influence on the solubility in 70 per cent alcohol by volume.

Probably the greatest relief home industry could receive would be by appropriate modifications of U. S. P. requirements in the coming edition, which would permit within reasonably practical limits the use of our globulus oil. The limitations should be sufficiently broad to include normal variations, particularly the solubility in 70 per cent alcohol by "volume." Among the proposed requirements are : specific gravity at 25 degrees—0.905 to 0.925 (same as at present); soluble in four volumes of 70 per cent alcohol (undoubtedly meaning 70 per cent by volume); and containing not less than 70 per cent cineol by the resorcin method.

However, if 70 per cent cineol is to constitute the minimum limit, then a gravity as low as 0.905 is unnecessary. The proposed solubility in four volumes of 70 per cent alcohol by volume with oils containing a minimum of 70 per cent cineol when the present U. S. P. calls for solubility in three volumes with not less than 50 per cent cineol, reverses the needs, since the solubility increases as the cineol increases. That is, if by increasing the solubility to four volumes, a more liberal scope is intended, the 70 per cent cineol makes this increase unnecessary and would be a solubility more in keeping with present U. S. P. requirements for 50 per cent cineol. If, on the other hand, a gravity of 0.905 (about that of California's) is meant to include the conditions of a broader range of oils, then the solubility in either three or four volumes of 70 per cent alcohol by volume is entirely inadequate; nor could a natural oil of this gravity contain as much as 70 per cent cineol.

SUMMARY.

1. Appropriate fractional distillation will render California eucalyptus oil up to present U. S. P. requirements, but at the expense of about 15 per cent of the original volume as determined by the present official method. The quality is further improved by the use of caustic soda.

2. Neither Australian nor California globulus oils in the raw state or redistilled in a current of steam are soluble in three or four volumes 70 per cent alcohol by volume, without fractionating, though this variety is not the competitive species we have to deal with in the Australian trade.

3. If the phosphoric acid method is retained as official in the coming U. S. P. the minimum per cent of cineol should remain as at present, 50 per cent. If the resorcin method is adopted the minimum per cent of cineol could be placed at 60 per cent without materially interfering with the California industry, but the proposed 70 per cent would entail a loss of at least 30 per cent of the original volume to bring it up to this figure if determined by the phosphoric acid method, and about 15 per cent loss if the cineol is determined by the resorcin method.

4. The solubility in 70 per cent alcohol by volume should be increased to at least eighteen instead of four volumes, if the average raw California oils redistilled in a current of steam without fractionating (Australian practice) are to be included on an equal basis with the foreign importations.

5. The by-product oil of refining as well as the crude (if sufficiently reasonable and in quantities) might be utilized for the separation of metallic sulfides by the flotation process, as extensively applied in Australia and to some degree here with the foreign oil.

* *Journal of Industrial and Engineering Chemistry.*

[1] Curator of the Technical Museum of Sydney. Baker and Smith—"A Research on the Eucalyptus with Particular Reference to Their Essential Oils," published by the Government of Australia in 1902.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