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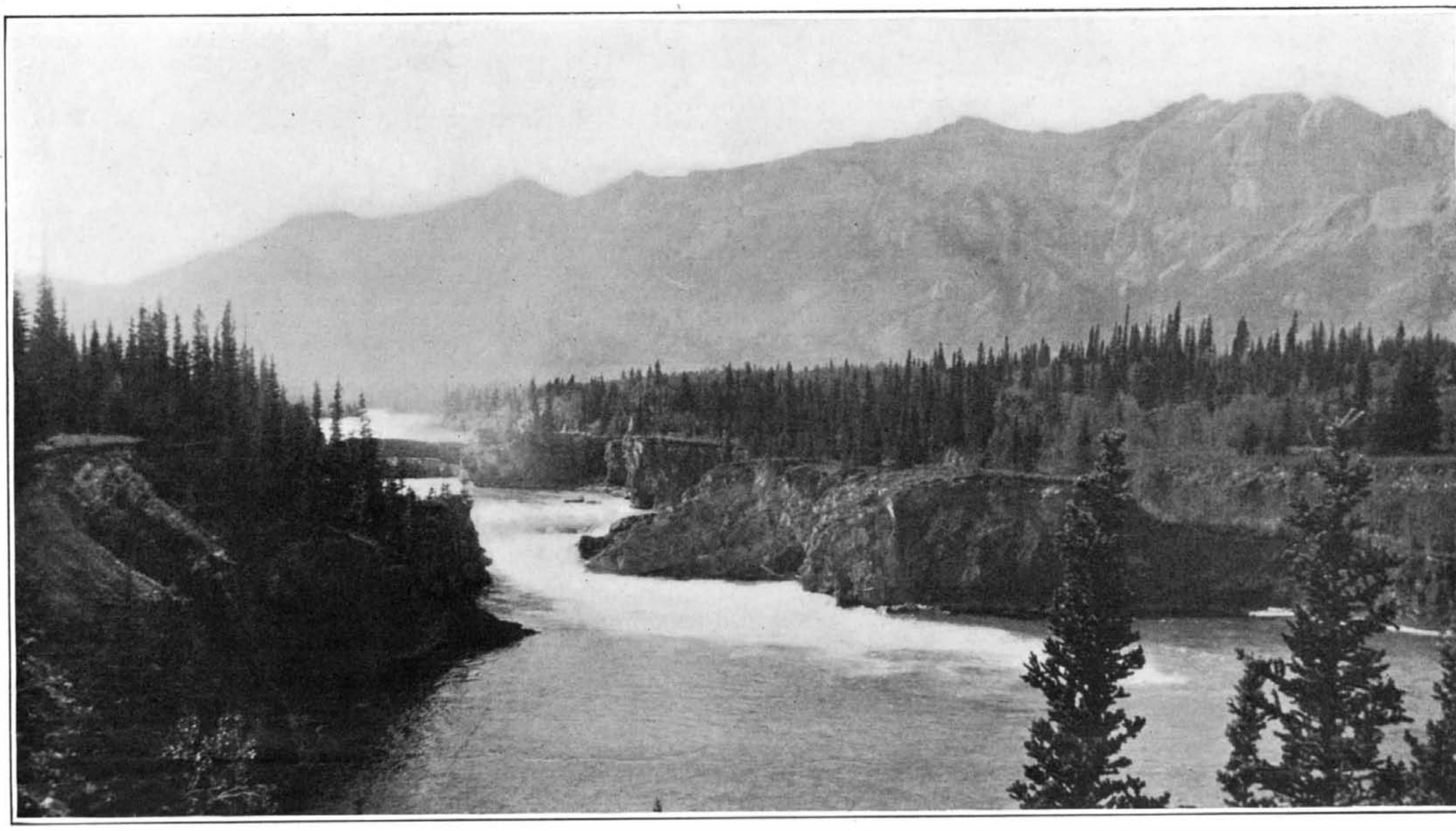
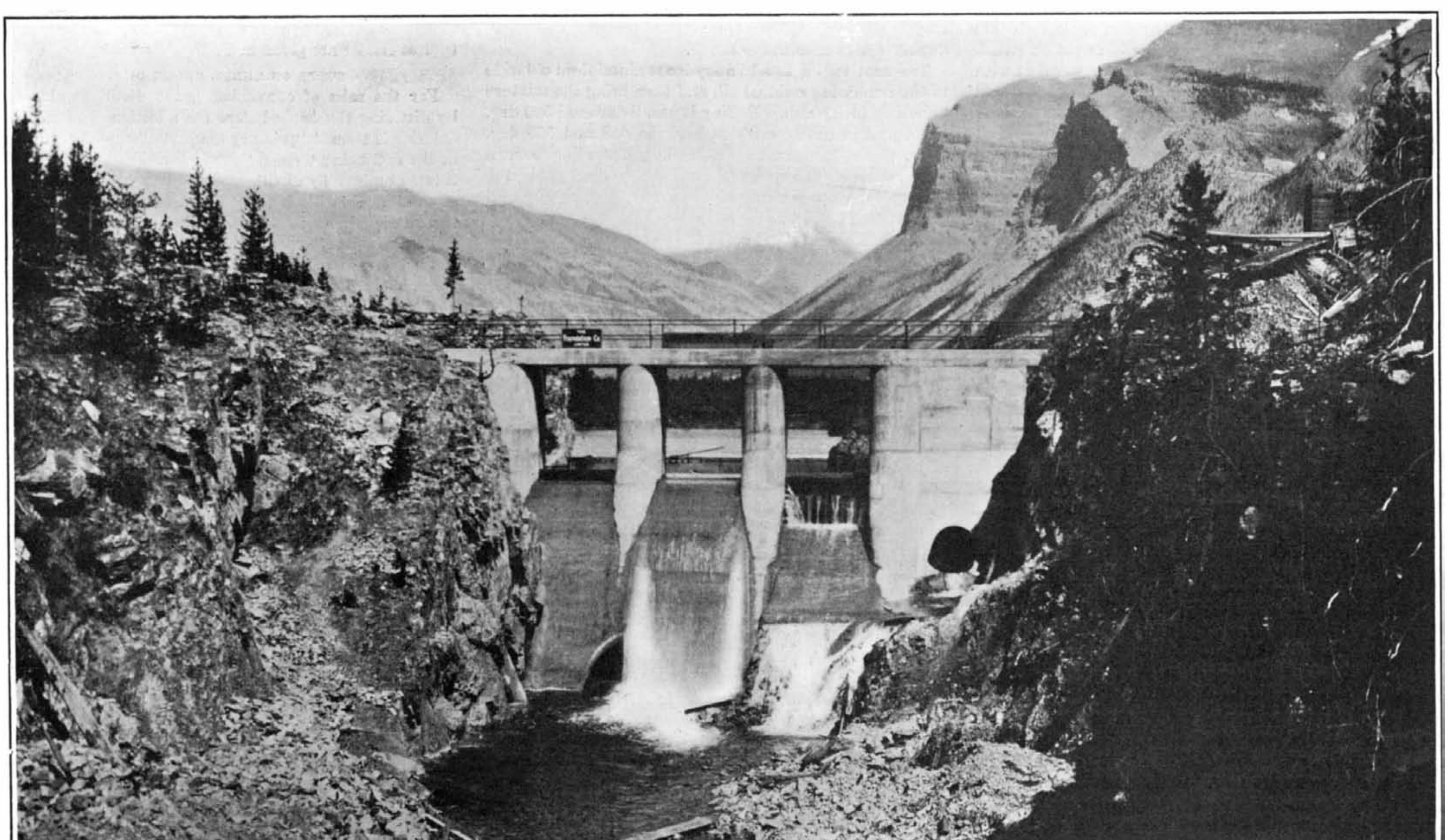


Kananaskis Falls, on the Bow River.



The Minnewanka Dam, near Banff, Alberta.

WATER POWERS OF CANADA.—[See page 56.]

The Improvement of the High Boiling Petroleum Oils—I*

By the Action of Aluminum Chloride

By A. M. McAfee

The conversion of high boiling petroleum oils into lower boiling oils of greater commercial value is an old problem, and many solutions of it have been proposed. Formerly, when kerosene was worth more than gasoline, naturally the effort was to increase the yield of kerosene from crude oil; nowadays, gasoline is worth more than kerosene, and naturally the effort is to increase the yield of gasoline. But in principle, gasoline making and kerosene making from high boiling petroleum oils are the same, and most of the proposed methods make both products. With very little variation, most of them will make gas equally well. A careful examination of these methods will show, in nearly all cases, the same principle, namely, what is called cracking—heating to a sufficient temperature to cause the high boiling oils to become unstable and break down into lower boiling oils. If the heat be intense enough and the time be long enough the product will be gas; less heat and a shorter time will make gasoline, and a still less heat and shorter time will make kerosene.

The inventors have rung the permutations on this simple idea; they heat under pressure and they heat under vacuum; they heat in the presence of gases; they heat in the presence of catalysts; they heat in tubes and they heat in boilers, etc. It is safe to say that in 99 per cent of the methods which have been proposed for converting high boiling oils into lower boiling oils, "cracking" by heat is involved. Sometimes it is disguised in ornate language; sometimes it lurks behind intricate apparatus, but it is always there.

The difficulty, however, with all these cracking methods is a difficulty in principle. In breaking down the complex, high boiling hydrocarbons into several simpler ones, there is not enough hydrogen to saturate these newly formed bodies, and unsaturated hydrocarbons must necessarily result unless hydrogen be added or carbon subtracted. Hydrogen is too expensive and difficult to add and though a part of the carbon is readily enough subtracted and deposited, this subtraction and deposition never goes far enough—although the still man might not be readily convinced of this. These cracked products are in large part unsaturated, and they are not desirable commercially. They are foul smelling; they are yellow in color and become rapidly more yellow on standing; they deposit large amounts of carbon on ignition in a gas engine; they burn with a smoky flame; they contain resinous bodies which cause gumming in use or on standing, etc. They can, of course, be refined somewhat with sulphuric acid, but there must be too much of the acid used and too much of the oil is lost to permit in practice any thorough treatment with acid.

Aside from the poor quality of the liquid products obtained, the operation of the cracking process is attended with great difficulty where uniform results are desired. There are many variables on which the obtaining of such results depends—temperature, time, pressure and catalytic action of the walls of the containing vessel. A change in either of these variables makes a change in the products obtained. Using the same apparatus, the same pressure, and consuming the same time, a difference of a comparatively few degrees of temperature in cracking operations makes marked differences in the yield and quality of liquid products.

In most of the cracking processes, pressure is employed: 60 to 100 pounds is usual and some have proposed much higher pressures. It is here that the greatest difficulty becomes manifest—the great danger to the operators and to the plant. There is always a deposition of hard (and flinty hard) coke on the inner walls of the heating element. Some who have had considerable experience in cracking oils have said that the coke is forced into combination with the iron, making it brittle and thus utterly unable to withstand the high temperature and pressure employed. At any rate, the deposition of the carbon occurs where the element is hottest, causing a local overheating at that point. Under such conditions the tensile strength of the steel becomes an unknown quantity; as likely as not it yields to the stress without any warning. Oil vapors of a temperature around 650 deg. Fahr. ignite spontaneously when they evolve from a still into the surrounding atmosphere. In cracking processes the temperature is 750 to 850 deg. Fahr. and even higher; hence, the manifest danger of cracking petroleum oils under such pressures.

When I took up the gasoline problem, some two and one half years ago, I dismissed from consideration the idea of cracking oils. Up to this time, or since the Friedel and Crafts British patent, No. 4769, of 1877, there had been some degree of mild interest shown as regards the effect which aluminium chloride might have on petroleum oils, but no positive results had followed from this interest. It appeared to me that this reaction might have far more significance than was then apparent. I trust this paper may exemplify its significance.

I have found that with proper control of the vapors leaving the distilling system and entering the final condenser, and with sufficient time given the aluminium chloride, high boiling oils can be completely broken down into lower boiling oils, and no matter how unsaturated the high boiling hydrocarbons may be, the low boiling oils produced therefrom are sweet smelling, water white and saturated. The reaction gives little gas and only about the right amount of carbon to allow production of saturated products. The carbon is deposited, not in the form of a hard baked-on carbon, but as a granular, coky mass, easily removed from the still.

But there are other products than gasoline that can be made from petroleum which are commercially worth while, although in our efforts to increase the supply of gasoline we have apparently forgotten this fact. If the market value of the various products which can be obtained from crude petroleum be plotted, it will be found that there is a peak at the low boiling end and another at the high boiling end. Gasoline is worth more than kerosene and kerosene is worth more than gas oil, while the products following gas oil, paraffin and lubricating oils, are worth as much or more than the gasoline.

The problem before me, therefore, knowing the reactive power of aluminium chloride, was to apply it to crude petroleum so that good heavy oils could be obtained while at the same time converting the less valuable portions of the crude into gasoline. The solution of this problem is found in my patent.

In the practical operation of this process, crude petroleum of any kind is first distilled until the naturally occurring gasoline and kerosene, if there be any present, is distilled off. As you are probably aware, in many of our crude oils, and especially some of those from Texas, California and Mexico, there is substantially no gasoline present and very little kerosene. But in any event, the crude is first heated to free it of any moisture which it may contain, since the oil must be perfectly dry before adding the aluminium chloride.

The next step is to add anhydrous aluminium chloride to the remaining residual oil, and then bring the mixture to boiling in the still. Boiling is usually around 500 deg. Fahr. and generally remains between 500 and 550 deg. Fahr. during the entire distillation, extending over a period of 24 to 48 hours. There is no need of employing extra pressure or vacuum or special apparatus; any still with a stirrer in it suffices.

Granted sufficient time for the aluminium chloride to get in its work, the success or failure of this process depends upon the proper control of the temperature at which the oil vapors are allowed to leave the distilling system to enter the final condenser. Between the still and the final condenser are placed two air-cooled condensers in series, which separate the low boiling oils from the high boiling oils, returning the latter, together with any volatilized aluminium chloride, to the still. For a 1,000 barrel still the air condensers which we are now using are drums of oval cross-section, 3 feet by 6 feet by 6 feet high. In addition to the air condensers, a 3 foot dome is attached to the top of the still which serves to return most of the volatilized aluminium chloride and its compounds. The operation is so controlled that the vapor is kept at the desired temperature as indicated by a thermometer placed in the vapor line at the point of exit of vapor into the final or water-cooled condenser. The temperature at this point should not exceed 350 deg. Fahr., otherwise not only will heavy oils distill over, but the aluminium chloride (or its compounds with hydrocarbons) will enter the condenser and clog it up. Under the first named condition, the distillate obtained will be a mixture of gasoline, solvent oil and kerosene, which are afterward separated by fractional distillation. These products are all water white, sweet smelling, saturated, and need no refining with sulphuric acid. In practice, no treatment is given them, except a washing with alkali, followed with water, to remove hydrogen sulphide. With proper back-trapping of high boiling oils into the still from the air-cooled condensers and a temperature of 300 deg. Fahr. in the vapor line, the distillate obtained will be gasoline alone, which is ready for the market when washed with an alkaline solution.

I have spoken of the time which should be given the aluminium chloride for the accomplishment of the desired results. It is a mistake to assume that with a given amount of aluminium chloride and boiling it up with oil, the desired results will be obtained. That is far from the truth. I do not wish to impose upon your patience by dismissing consideration of the mechanism of this reaction by simply saying it is catalytic. I am fairly well satisfied that it is one of association or combination in the liquid phase and dissociation in the vapor phase. It is well known that aluminium chloride exists in the solid and liquid states as Al_2Cl_6, and in the vapor state as $AlCl_3$. It is also well known with what avidity aluminium chloride in the solid or liquid state will combine with other salts to form double salts. The most common of these double salts is that of aluminium and sodium chloride which, at one time, as you know, was the source of metallic aluminium (Castner process). Aluminium chloride probably combines with these high boiling, complex hydrocarbons in much the same way as it combines with sodium chloride and when the boiling temperature is reached these double compounds become unstable and dissociate into lower boiling hydrocarbons, which, under the temperature control imposed in the vapor line, leave the distilling system as fast as produced; Al_2Cl_6 is again formed and is capable of combining further with other high boiling hydrocarbons remaining in the still, and free carbon is formed simultaneously. This view of the reaction here involved is confirmed, I believe, by the operating conditions mentioned heretofore as necessary for obtaining the desired results.

While the operation, using crude oil as the starting material, can be carried on to produce larger or smaller quantities of gasoline, in practice it is carried on so as to convert the gas oil fraction into low boiling hydrocarbons and leave most of the high boiling hydrocarbons, that is, the paraffins and lubricating oils. Accordingly, the operation is interrupted after a portion of the crude has been converted into low boiling products, and the high boiling oil remaining in the still is pumped off while hot; on cooling it is worked up into the usual paraffin and lubricating products. The aluminium chloride remains in the still enmeshed in a mass of coke, and the methods of its recovery are found in my patents.

As illustrative of the action of aluminium chloride on high boiling petroleum oils, results obtained on typical crudes are given in Tables I to III.

TESTS ON THREE CRUDE OILS.

For the sake of convenience, the distillate obtained by distilling the crude before the addition of aluminium chloride is termed "primary distillate," the oil remaining in the still being termed "primary residual oil;" the distillate obtained by distilling the primary residual oil with aluminium chloride is termed "secondary distillate" and the oil remaining in the still, "secondary residual oil." Fahrenheit temperature and Baumé gravity are used throughout. The distillation tests were made on 100-cubic centimeter samples contained in standard Engler flasks connected to a 22-inch Liebig condenser. All flash points noted are in open cup tester. Viscosities noted are on the Saybolt universal viscosimeter at 100 deg. Fahr. W. W. and S. W. are abbreviations for water white and standard white, respectively.

Texas Crude Oil.—In ordinary practice no gasoline is obtained from this type of Texas crude (sp. gr. 20.8 Bé). By the aluminium chloride process (see Table I) 17.75

TABLE I—TESTS ON TEXAS CRUDE OIL

(SP. GR. 20.8 DEG. BE.)

Distilled until Free from Moisture and until the Naturally Occurring Gasoline and Kerosene Had Been Distilled Over.

YIELD FROM CRUDE OIL.

	Per Cent Crude Oil.
Primary distillate	7.14
Primary residual oil	91.26
Loss	1.60
Total	100.00

TESTS ON PRIMARY DISTILLATE.

Sp. gr. 36° Bé. Bromine No. 5.46

Distillation over 260° Fahr.

Per cent	10	20	30	40	50	60	70	80	90	95
Up to	320°	344°	368°	386°	400°	442°	468°	490°	505°	520° F

Fractional Distillation.	Per cent crude.	Sp. gr. ° Bé.	Color.	Per cent sulphur.	Bromine No.
Gasoline	0.303	58.0	W. W.	0.065	4.8
Gas naphtha	0.180	51.0	S. W.	0.103	3.1
W. W. kerosene	1.260	41.6	W. W.	0.071	...
S. W. kerosene	1.530	40.9	W. W.	0.133	...
Gas oil	3.791	31.2	......	0.383	...
Loss	0.076				
Total	7.140				

* Read before the Seventh Semi-Annual Meeting of the American Institute of Chemical Engineers, San Francisco, August 25th, 1915.

TESTS ON PRIMARY RESIDUAL OIL.

Sp. gr. 19.8° Bé. Viscosity 302

Distillation over 480° Fahr.

Per cent	10	20	30	40	50
Up to	530°	566°	600°	656°	680°

Mixture of Primary Residual Oil and 7.5 Per Cent by Weight of Anhydrous Aluminium Chloride Brought to Boiling.

	Temperature of Distillate.				Distillation Test.			
Time.	Still ° F.	Vapor line.	Per cent charge.	Sp. gr. ° Bé.	Over ° F.	P. C. below 350°	450°F	Dry point.
1:00 P.M.	454	268	Showed up	...	...	..	..	...
1:30 P.M.	479	290	2.86	55.9	110	68	80	490
1:45 P.M.	488	300	2.86	55.2	110	69	84	490
2:15 P.M.	495	302	2.86	54.4	110	66	80	490
2:45 P.M.	504	290	2.86	54.1	110	66	81	490
3:15 P.M.	508	290	2.86	53.5	110	65	80	490
4:15 P.M.	518	340	2.86	53.7	110	65	80	490
4:45 P.M.	523	340	2.86	53.7	110	65	83	490
6:00 P.M.	525	340	2.86	53.5	105	60	82	490
7:00 P.M.	530	344	2.86	53.3	100	58	81	490
8:30 P.M.	530	340	2.86	53.5	100	58	81	490
10:30 P.M.	542	340	2.86	53.2	100	60	83	490
1:00 A.M.	547	320	2.86	52.6	100	60	83	490
4:00 A.M.	547	320	2.86	52.4	100	60	83	490
6:30 A.M.	552	290	2.86	52.8	100	58	83	495
10:00 A.M.	551	305	2.86	50.6	100	58	83	500
1:00 P.M.	557	302	8.57	49.7	100	55	85	510

From back trap, 1.39

Operation stopped at end of 24 hours.

YIELD FROM DISTILLATION PRIMARY RESIDUAL OIL WITH $AlCl_3$

	Per cent charge.	Per cent crude.
Secondary distillate	52.86	48.24
Secondary residual oil	31.14	28.42
Loss (gas and coke)	16.00	14.60
Total	100.00	91.26

TESTS ON SECONDARY DISTILLATE.

Sp. gr. 51.1° Bé.

Distillation over 100° Fahr.

Per cent	10	20	30	40	50	60	70	80	90	95
Up to	174°	228°	265°	294°	324°	357°	388°	428°	475°	500° F

FRACTIONAL DISTILLATION.

Fractions.	Per cent charge.	Per cent crude.
Gasoline	36.18	17.45
Gas naphtha	26.62	12.85
W. W. kerosene	2.65	1.28
S. W. kerosene	9.53	4.59
Gas oil	21.80	10.52
Loss	3.22	1.55
Total	100.00	48.24

PROPERTIES OF FRACTIONS.

	Gasoline.	Gas naphtha.
Color	W. W.	S. W.
Odor	Sweet	Sweet
Bromine No.	4.2	3.2
Dry test	O. K.	O. K.
Heat test	4	3
Sulphur	0.056%	0.054%
Gravity	64.5	50.2

Distillation of Gasoline Fraction—Above 117° Fahr.

Per cent		10	20	30	40	50
Up to		160°	170°	179°	190°	208°
Sp. gr.		82.1	79.0	75.3	70.9	66.0
Per cent	60	70	80	90	98 (dry point)	
Up to	222°	239°	261°	293°	339° F.	
Sp. gr.	61.8	57.7	64.2	50.4	...	

Distillation of Gas Naphtha Fraction—Above 215° Fahr.

Per cent		10	20	30	40	50
Up to		240°	246°	253°	260°	270°
Sp. gr.		57.0	55.0	54.1	52.8	51.3
Per cent	60	70	80	90	98 (dry point).	
Up to	280°	293°	306°	332°	350° F.	
Sp. gr.	50.2	49.1	47.5	45.4	...	

TESTS ON SECONDARY RESIDUAL OIL (FREED OF $AlCl_3$)

Color.	Flash test.	Fire test.	Viscosity.
Red-green bloom	185° F.	250° F.	105

Secondary Residual Oil Reduced with Steam.

Yield.	Per cent charge.	Per cent crude.
Gas oil	10.00	2.84
Lubricating oil	90.00	25.58
Total	100.00	28.42

TESTS ON LUBRICATING OIL.

Color	Red-green bloom
Sp. gr.	21.9
Flash test	290°
Viscosity	122

SUMMARY.

Products from $AlCl_3$ Process (Per Cent Crude Oil).

Distillate.	Gasoline.	Gas naphtha	Kerosene.	Gas oil.	Lubricating oil.	Total.
Primary	0.30	0.18	2.79	.....	.....	82.17
Secondary	17.45	12.85	5.87	17.15	25.58	
Loss Due to:						
Distilling primary distillate					1.60	17.83
Distilling with $AlCl_3$					14.60	
Redistillation of primary distillate					0.08	
Redistillation of secondary distillate					1.55	
Total						100.00

COMPARISON OF $AlCl_3$ PROCESS WITH USUAL PROCESS.

Per Cent of Crude Oil By—	$AlCl_3$ process	Usual process
Gasoline	17.75	0.00
Gas naphtha	13.03	0.10
Kerosenes	8.66	4.30
Gas oil	17.15	52.00
Lubricating oils	25.58	25.50
Asphaltic residual oil	.....	12.00
Sum of Products	82.17	93.90
Loss	17.83	6.10
Total	100.00	100.00

per cent is obtained and those who are familiar with the tests on petroleum products will see that this gasoline is as good as the natural gasoline made from any crude petroleum. The gas naphtha, which might very well be mixed with the gasoline, has been increased from 0.1 to 13.03 per cent. It will be observed that these low boiling oils have been made at the expense of the gas oil fraction and the asphaltic residual oil, the latter being broken down completely. Gas oil is the least valuable constituent of the crude. The asphaltic residual oil is used for fuel or is made into asphalt. The yield of lubricating oil by the aluminium chloride process is about the same as that in the usual process, but the quality of the former is greatly improved by virtue of the saturating effect of the aluminium chloride and the elimination of asphaltic and resinous constituents from the oil.[1]

It will not be necessary to go into so much detail with the remaining crudes of which I desire to speak, but I have wanted to give you these figures on Texas crude to show how regularly the reaction proceeds over a long period of time, what the physical characteristics of the products are, and the yield as compared with the usual process.

Caddo (La.) Crude Oil.—This crude (sp. gr. 41 deg. Bé.) belongs to the same type as Pennsylvania crude, the type known as paraffin-base crudes. Their products are clean smelling and require but little acid in refining. But even this type of crude is considerably improved by the aluminium chloride process (see Table II), while at the same time the yield of gasoline is greatly increased. The paraffin residual oil from Caddo crude is black and tarry on account of the presence of asphaltic constituents, but these are not usually present in large enough amounts to prevent the manufacture of good paraffin and paraffin lubricating oil. The distillation with aluminium chloride destroys the asphaltic constituents, giving an amber colored residual oil which may be easily worked into a product known commercially as vaseline, or into paraffin and paraffin lubricating oils. At the same time the yield of gasoline from the crude is increased from 18 to 42.32 per cent.

TABLE II.—TESTS ON CADDO (LA.) CRUDE OIL (SP. GR. 41° BÉ.)

Distilled to Free It from Moisture and Natural Gasoline.

YIELD FROM CRUDE OIL.

Primary Distillate.	Primary Residual Oil.	Loss.	Total Per Cent.
26.19	71.43	2.38	100.00

TESTS ON PRIMARY DISTILLATE.

Sp. gr. 58.2° Bé.

Distillation over 160° F.

Per cent		10	20	30	40	50
Up to		215°	232°	247°	260°	276°
Per cent	60	70	80	90	95 (dry point)	
Up to	296°	315°	343°	402°	450°	500°F.

Fractional Distillation.	Per Cent Charge.	Per Cent Crude.
Gasoline	82.00	21.48
Kerosene	15.00	3.93
Loss	3.00	0.78
Total	100.00	26.19

Mixture of primary residual oil and 5 per cent by weight of aluminium chloride was brought to boiling and distilled during period of 48 hours. Temperature of the vapor line at the point of exit into final condenser was held around 350° F.

YIELD FROM $AlCl_3$ DISTILLATION OF PRIMARY DISTILLATE.

	Per Cent Charge.	Per Cent Crude.
Secondary distillate	58.33	41.67
Secondary residual oil	26.20	18.71
Loss (gas and coke)	15.47	11.05
Total	100.00	71.43

TESTS ON SECONDARY DISTILLATE.

Sp. gr. 54.0° Bé.

Distillation over 102° F.

Per cent	10	20	30	40	50	60
Up to	212°	260°	293°	315°	340°	365°
Per cent	70	80	90	95	98 (dry point)	
Up to	388°	414°	450°	480°	500° F.	

FRACTIONAL DISTILLATION.

Fractions	Per cent Charge	Per cent Crude
Gasoline	50.00	20.84
Solvent oil	40.00	16.67
Gas oil	6.00	2.50
Loss	4.00	1.66
Total	100.00	41.67

PROPERTIES OF FRACTIONS.

	Gasoline	Solvent oil
Color	W. W.	W. W.
Odor	Sweet	Sweet
Bromine No.	2	3
Dry test	O. K.	O. K.
Heat test	2	2
Sp. gr.	58.0	48.1

Distillation of Gasoline Fraction—Above 120° F.

Per cent		10	20	30	40	50
Up to		198°	221°	240°	258°	272°
Per cent	60	70	80	90	95 (dry point)	
Up to	288°	301°	322°	348°	362° F.	

Distillation of Solvent Oil Fraction—Above 340° F.

Per cent	10	20	30	40	50	60
Up to	354°	360°	364°	369°	374°	381°
Per cent	70	80	90	95 (dry point)	98 (dry point)	
Up to	390°	400°	416°	430°	440° F.	

TESTS ON SECONDARY RESIDUAL OIL.

Color.	Sp. gr.	Flash test	Fire test	Pour test
Red-green bloom	36.5° Bé.	260° F.	300° F.	90° F.

Secondary Residual Oil Distilled.

Yield.	Per Cent Charge.	Per Cent Crude.
Gas oil	30.00	5.61
Paraffin residual oil	70.00	13.10
Total	100.00	18.71

Tests on Paraffin Residual Oil.

Color	Flash test	Fire test	Pour test
Amber	375° F.	420° F.	105° F.

[1] Samples of the products were furnished for examination.

SUMMARY.

Products from $AlCl_3$ Process (Per Cent Crude Oil)

Distillate	Gasoline	Solvent oil	Kerosene	Gas oil	Paraffin residual oil	Total
Primary	21.48		3.93	....	.....	84.13
Secondary	20.84	16.67	....	8.11	13.10	
LOSS DUE TO:						
Aluminium chloride distillation					12.71	15.87
Working distillates into standard products					3.16	
Total						100.00

COMPARISON OF $AlCl_3$ PROCESS WITH USUAL PROCESS.

Per Cent of Crude Oil.	$AlCl_3$ Process.	Usual Process.
Gasoline	42.32	18.00
Solvent oil	16.67	12.00
Kerosene	3.93	35.00
Gas oil	8.11	21.00
Paraffin residual oil	13.10	11.00
Sum of Products	84.13	97.00
Loss	15.87	3.00
Total	100.00	100.00

(To be concluded.)

Fire-proofing Stage Scenery

AS FAR back as 1820 the eminent French chemist, Gay-Lussac, endeavored to find a practicable fire-proofing for the canvas scenery used in stage settings. But his efforts and subsequent ones have been so far from satisfactory that infringements of the law requiring incombustible scenery have been only too common in Paris, says *La Nature* (Paris). The great difficulty with the various methods proposed has been that in the course of time they caused an alteration in the materials used and modified the colors of the decorative painting.

Very recently, however, the Director of the Municipal Laboratory in Paris, who has been making extensive investigations and experiments on the subject, announced a complete success in discovering a method of fire-proofing not only free from the objections stated above, but having the merits of cheapness and ease of application. In his report upon the subject, recently presented to the Commission on Theatres of the Prefecture of Police, he states that the cost of his new process, whose merits are acknowledged and attested by a number of well-known theatrical scene-painters, is only five centimes (one cent) per square meter of canvas, including the required labor. The fire-proofing solution may be applied to the canvas like paint, or the fabric may be impregnated with it by means of soaking.

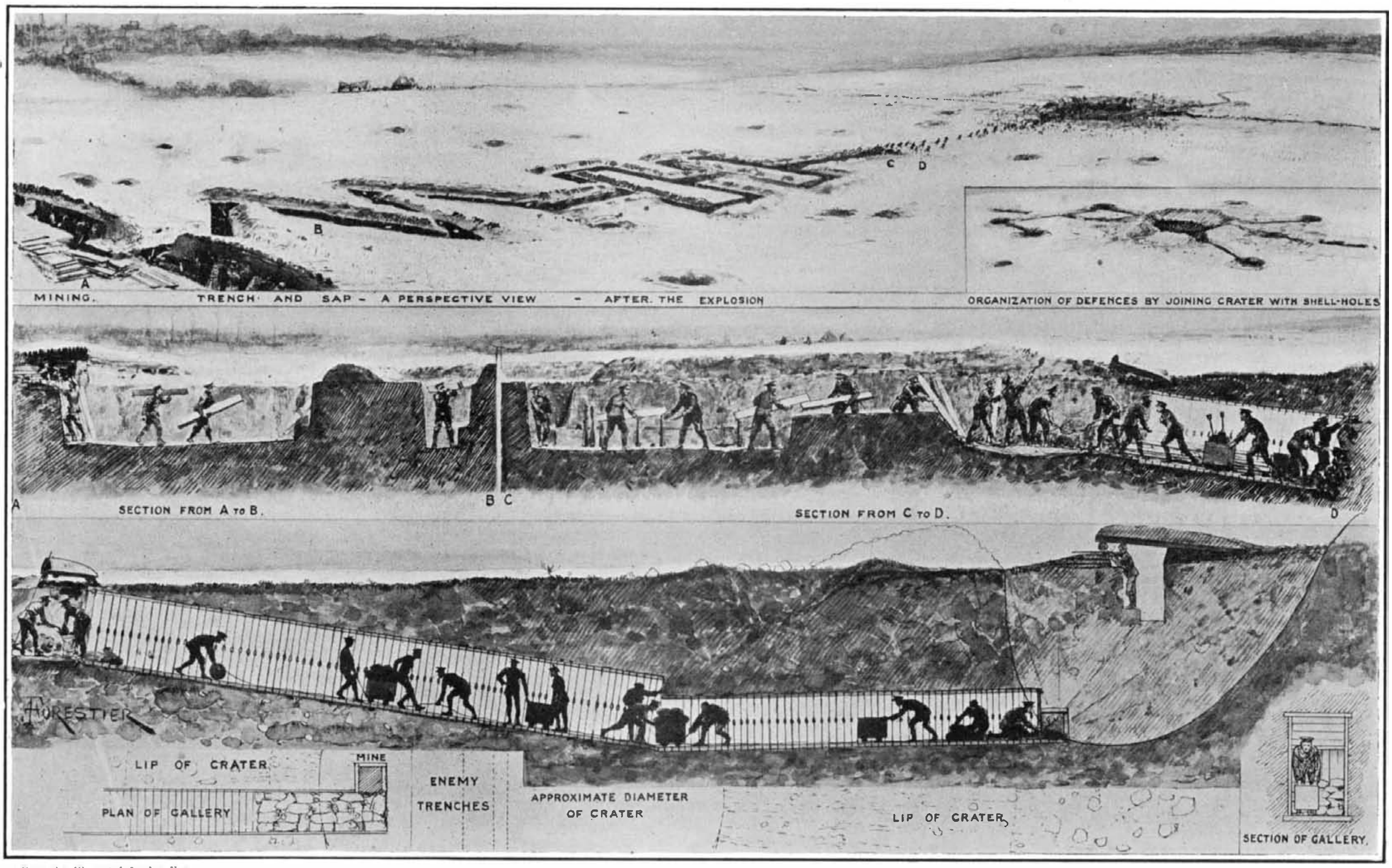
The solution consists of 50 grammes of boric acid plus 60 grammes of borax dissolved in one litre of water. When the cloth is soaked it is taken out of the bath after being thoroughly impregnated, is allowed to drip till excess of solution is removed, and is then dried either by evaporation in the air, or by being ironed with hot irons.

It is advisable, however, that the protective substance be applied like paint to canvas meant to be covered with decorative paintings. This method has the advantage that the painter may fire-proof his canvas at the same time that he prepares its surface in the usual way to receive the paint. To this end he merely dissolves in the sizing of Spanish white commonly employed, about 200 grammes per litre of the mixture of boric acid and borax above described. To obtain perfect incombustibility about one-half litre per square meter of the protective mixture must be "fixt" on the canvas.

Mr. Kling states that after very numerous experiments with all sorts of reagents, he was convinced that the fire-proofing action of the mixture is not due, as has been supposed, to the formation of an inert gas, but that the efficacious substances are principally composed of salts or saline mixtures capable of melting at low temperatures. When acted on by heat, these substances form a layer or "glaze" which protects the fabric from coming in contact with the air.

Fitting Motor Truck Rims

AN ingenious method of heating motor truck wheel rims is employed by one of the large manufacturers. The tires, which have to be heated before being pressed on to the wooden wheels, are heated electrically by being laid in a steel tub around a transformer coil. The tire thus forms the secondary and is heated in a similar manner to the metal in an induction furnace. In three minutes a tire about ½ inch thick, 10 inches wide and 36 inches in diameter can be heated to the required temperature, which is just about sufficient to make the ash wheel smoke. The advantages are that there is no danger of fire in the wood-working shop and that the tires are heated quickly and uniformly without being sooted or oxidized.



From the *Illustrated London News*

In this diagramatic sketch a variety of trenching operations are shown, as well as the methods of constructing a mine for blowing up a position of the enemy. The main line of trenches is shown at *A* in the upper sketch. At *B* are zig-zag advance or connecting trenches, while further along is a construction for enabling a strong body of troops to be concentrated in advance of the main body. The mining tunnel starts at *C*. The other sketches are self-explanatory.

Trenching and Mining Operations

Important Underground Maneuvers in the War

The digging in process, which is the characteristic feature of the field operations of the present war, has become a highly developed technical maneuver, and the armies on both sides have become very expert in underground operations. In the accompanying illustration, taken from the *Illustrated London News*, the main line of trenches is shown at *A* in the upper portion of the picture; and the zig-zag extensions show how advance lines are gradually worked forward, a few yards at a time. If a trench was driven straight forward in a direct line opposing forces would quickly find a position from which they could sweep its entire length with a deadly and irresistible fire; so the advance is made by a series of angles, with but a few yards in any one direction.

In the middle distance of this sketch will be seen two large rectangular sets of trenches, which are designed to permit of the concentration of a larger number of troops than could be accommodated in the narrow advance trench, and here they are ready to take advantage of any opportunity for a rush forward, or to repel a sudden assault.

There is another important operation that goes hand in hand with trench digging, and that is mining, for there are land mines as well as the submarine kind. It frequently happens that one force occupies a particularly advantageous and also impregnable position which it has been found impossible to force either by shell fire or assault, and in this case the besiegers endeavor to overcome it by mining and blowing it up. Such was the case of the notable "Hill No. 60" that was held by the Germans against the French.

In making an attack of this kind the regular trenches are pushed forward as far as possible toward the coveted position and then a gradually descending tunnel is driven forward at a carefully calculated angle. Gradually and carefully the earth is scooped out and passed back, as shown in two of the sketches in the plate, until a position directly below the enemies' trench is attained, and here a heavy charge of explosives is placed and fired at the right time, destroying both the position and its defenders.

Accompanying the explosion there is usually a rush of the besieging forces to occupy the crater formed by the explosion, and here they rapidly create a new fortification of their own, for the excavation formed by a great charge of high explosives is often big enough to accommodate a powerful force of men, and the material thrown out forms quite a strong rampart around the sides.

Naturally these mining operations are not confined to one side, and it sometimes happens that the side being mined gains a knowledge of the operations of the enemy, and at once starts counter operations by endeavoring to burrow below the first mining operation. Then success attends the party that completes its tunnel first. In any case, expeditious work is essential.

The Heart of the Athlete

At a meeting of the Medical Society of the State of Pennsylvania, Dr. Robert N. Willson of Philadelphia said that two vital questions involved in college and schoolboy competitive athletics were: (1) The ultimate (post-graduation) result of public competitive athletics upon the health and lives of the participants; (2) the possibility of determining the genuine physical integrity of the proposed participant or his lack of the same, especially with respect to his heart. Reference was made to the many deaths in recent years among former athletes. He knew of no instance of recovery from a major infectious disease in an athlete, except in the typhoid epidemic at Easton, where a number of undergraduates—probably not then shorn of their resisting forces—had made a successful fight and recovered. It was to be remembered that the normal heart would not tolerate repeated insults without loss of recuperative power. Latent athletic injuries would seem to explain the tendency of the strong and robust to die when the less powerful won out against infectious disease. A still more radical evil was the encouragement offered by college and university to the schoolboy to emulate his college brother in competitive athletics. Dr. Willson said that he stopped short of advising against active competition as the Germans had, but pointed rather to signboards written in bold letters. Trainers should be taught the meaning of the collapse of to-day in the future of the athlete. He believed that some day college authorities must of necessity conclude that no form of athletic event was sane which demanded of the participants the semicouscious state of heart exhaustion at its conclusion.

Rat-Fleas and Rat-Trypanosomes

We owe to the late Prof. E. A. Minchin and to Dr. J. D. Thomson an account of the linkage between the rat-trypanosomes (*T. lewisi*) and the rat-flea. The fully developed trypanosomes are found in great numbers in the blood of an infected rat, but they are never transmitted directly from one rat to another. Their intermediate host is the common rat-flea (*Ceratophyllus fasciatus*), which ingests the parasites with the rat's blood. Within the alimentary canal of the flea the trypanosomes, if they succeed in establishing themselves—which they apparently do in only about twenty-five per cent of cases—go through a development cycle, and this has been minutely studied and figured by the authors. Of more general interest is the question as to how the parasite is transmitted to a fresh rat by the flea; and to determine this a series of experiments was made. Clean rats muzzled, so that they could neither lick nor scratch, with wire gauze too fine for fleas to penetrate, were put into bell-jars with two hundred hungry fleas from the infected cage, and left there all night. When taken out they were freed from fleas, their fur was washed with a disinfectant, and carefully dried, and they were then allowed to lick as they pleased. In no case did such rats show infection except when they had succeeded in tearing off the muzzle. All the experiments went to prove that infection takes place through the mouth, either by the rat eating the fleas or licking the moist fecal matter from its fur. Infection is never conveyed through the proboscis of the flea, which, indeed, never shows trypanosomes in its salivary glands. There remains the possibility that trypanosomes from the fecal matter penetrate through the puncture made by the flea's proboscis, but the balance of evidence is in favor of infection by the mouth alone.—*Knowledge.*

How Trees Heal Their Wounds*

Remarkable Powers of Recovery from Injuries by Vegetable Life

The violent battles that have taken place in European forests during the present war, for example, in places now famous like Le Gruerie or Le Prêtre, have left for one result large numbers of trees wounded by shell or shrapnel. It is lamentable to see how the poor things are crisscrossed by the holes of machine-gun bullets or checker-boarded by the bursting of shrapnel. Many among them are dead and gone, but a goodly number are merely hurt and in time the forests may resume their former strength. It is interesting to see what the plant can do for itself when wounded.

Vegetables have remarkable powers of recovery from injury; some of which seem to work to the benefit of the plant as a whole. This fact is of value to florists and gardeners, who take advantage of it by cutting back certain groups.

It is well known that vegetables have "dormant buds," which, so long as the growth is normal and regular, remain absolutely quiescent even for years. But if on the contrary a branch be cut and the growth of the plant be slowed locally for a while, such buds come immediately into action. They wake and grow and expand into little branches which cover themselves with leaves and replace as nearly as may be the branches that have been lost.

Another mode of healing wounds in vegetables, at least the injuries that are superficial, is by the change of some of the cells into cork. The impermeability of this substance to liquids and gases need not here be discussed. The modification is easy of accomplishment, the cell walls become impregnated with suberine, the technical name for the cellulose of cork, the cell contents disappear and their place is taken by air. It is such a structure which accounts for the lightness of cork. Protective layers of cells changed in this way serve to shield injured places.

More often than this there ensues active cell-division at the wounded place, proliferation being the medical word, and a swelling is to be seen at the place of injury. The scar is often covered by later growths and by bark, and oftentimes the bullets are covered and held where only future wood-workers will find them.

All this has to do in general with superficial wounds. When they are deeper, when the ball traverses the bark and enters into the wood of the trees, the process is somewhat more complicated. In the linear ducts of the tree vesicles or droplets begin to form (Fig. 1), the result of a stimulated cell-making consequent on injury. The cells of the walls of the duct take part in this and the result is the checking of the flow of sap. This prevents bleeding or loss of tree liquids.

* From *La Nature*.

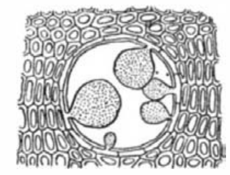
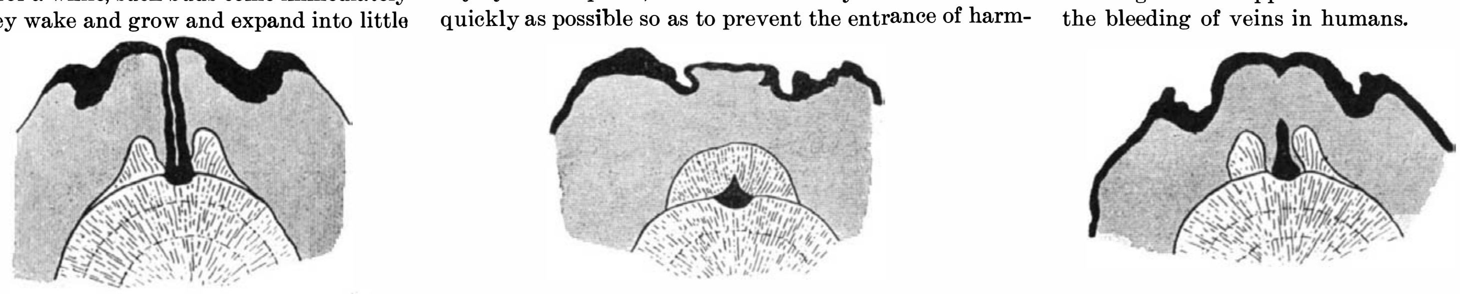


Fig. 1.—Cross section of wounded part of tree (magnified).

The large circle is a duct within which the droplets are forming from the cells of the walls of the duct.

But in order that such results follow, it is necessary that the wound be not a permanent source of sickness or injury to the plant, and it is necessary for it to heal as quickly as possible so as to prevent the entrance of harmful micro-organisms and injurious insect life, or at the very least to arrest the consequent flow of plant liquids the loss of which will very quickly result in the drying up of the plant.

Trees are in general well equipped with first-aid devices to heal their wounds. More fortunate than humans, they are able to apply automatically an antiseptic bandage to the injured place. As soon as the hurt is received the tree reacts at the damaged place. The local functions of the organism accelerate and at the same time proteid solutions flow toward the wound. The result is for a while, at least, an increase in vitality and in resistance toward weakening influences.



Figs. 2, 3, 4.—Cross sections of wounded branch in which the injury gradually heals.

It is to be noted that a goodly number of species of trees are provided with a duct system, these channels being filled with mucilaginous secretions, which, so soon as the wound is made, flow out, spread over the surface and protect it. This first-aid, instantaneous in its beginnings and of highest efficiency, is particularly noticeable in the pines, spruces and larches and others of the conifers, in which the resins flow very quickly. They form an impermeable protection above the injury. In possessing such qualities the vegetables may well reflect on their superiority to man.

This cicatrizing substance is particularly to be found in the longitudinal ducts of plants and has been closely studied by Mangin and other botanists. It forms in droplets on the inner walls of the broken canals, growing little by little and finally establishing the complete closure of the duct. The process is analogous to that of the surgeon who applies his haemostatic pincers to stop the bleeding of veins in humans.

Other species and families of trees, not equipped in this way, help themselves by another process. The wounded places change color, first to yellow and then to brown. This is due to the appearance of what may be termed "wound-gum," which is composed of various gums with tannins.

At the same time the bark is changing into cork to protect the wound. Then the cambium, or cells between the bark and the wood by which the new wood is formed, goes actively into cell making and not only is there new wood through which the sap can circulate but additions to the inner bark.

Out of such complicated processes there will result one of two things; when the wound is not serious all the new tissues join and help in the recovery of the injured part so that the wound is covered, or else recovery is effected without completely re-establishing the injured parts. In the first case the branch may become quite normal as in Figs. 2, 3 and 4. In the second case, where the wound is large and there remains more or less dead tissues and the tough plaque of wound-gum, the new wood and the new bark together form a large swelling, Fig. 5, always more developed above than below. Such trees may have a long life after cure although often much injured from the esthetic point of view.

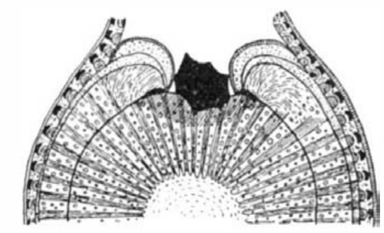


Fig. 5.—Cross section of branch with a shell fragment remaining and the healing process begun.

The swelling of the branch to enclose the fragment may be seen, and the wound gum is indicated below it and flowing to it by the shaded and short lines.

Prevention of Trench-Foot

Some time ago an article on "Trench Frost Bite" told of a trouble that soldiers in the trenches experienced last winter as a result of being compelled to stand in water for long periods. That it is a serious matter is evident from the fact that it has been found that when the malady was once established, no particular local treatment appears in any way to expedite a cure, and consequently a very large proportion, of the British soldiers affected were unable to return to service.

In a recent issue of *The Lancet* this subject is again discussed, and the facts herewith given are derived from that source.

After attention was called to the subject last year Prof. Sheridan Delepine did much experimental work on the subject, and conducted a series of experiments to determine the rate of the cooling of the extremities on immersion in cold water, with or without the addition of a waterproof covering, and of the presence of a layer of dry air or damp air between the waterproof covering and the skin. In summarizing his results he states that while the presence of a thick wool covering retards the loss of heat even when the covered part is plunged into water, this retardation is not sufficient to prevent the occurrence of local frigorism. On the other hand, a very thin layer of warm dry air between the skin and the cooling medium was sufficient to reduce the loss of heat to such an extent that the amount of heat brought to the part by the circulating blood then sufficed to compensate for the loss. A very thin waterproof covering used in combination with a woolen layer was found sufficient to secure a layer of warm dry air next to the skin. Other work was done under the guidance of the Medical Research Committee.

The conclusion of all authorities is that trench frostbite[1] was essentially similar to the stages of true frostbite before actual necrosis had occurred; and for prevention careful attention was enjoined to everything, such as boots and puttees, which might constrict the blood-vessels. Leggings were preferable to puttees in so far as they provided the protection of an ample cushion of air, and by draining more readily than compact wrappings, favored the rapid re-establishment after wetting of this non-conducting air-cushion. As far, therefore, as the causation of trench-foot is concerned, there is substantial agreement both between the authors of these experimental tests and those familiar with the conditions in the trenches. It is the rapid conduction of heat away from the limb the coverings of which have become wet and sodden, associated with the constriction of the limb by tight boots and puttees, which interferes with the continuous supply of heat necessary to compensate for the loss. Prof. Delépine's experiments were based upon the readings of a thermometer held in contact with the skin. He pointed out that it would also be possible to measure the actual quantity of heat lost in calories, and one of his experiments was designed to this end. Other similar experiments appear to show that the heat lost through exposure to cold water of the legs up to the knees may be as great as the total number of calories developed by the food in the course of twenty-four hours. Under normal conditions we have always supposed the diet of the soldier at the front to be abundant and even in excess of his physiological needs, but if the soldier is using his entire food ration to warm the water of the trench in which he stands, he evidently has nothing over for his personal needs. He is then exactly in the position of a man from whom food is entirely withheld.

A water-footed stocking was introduced last winter, perfectly waterproof and capable of being worn comfortably with the service boot. This stocking was tested on ten soldiers in artificial trenches at Beckenham, all of whom wore the same size of wader, although varying greatly in size of boot. An immersion in water at 32 deg. to 40 deg. Fahr. for a total period of 14 to 20 hours was practised, and at the end of the experiment the soldiers' feet were still comfortably warm and efficient.

[1] The proper name for this affection is still a matter of doubt. A name conveying some idea of the pathogenesis should be preferred, but *frost-bite* is inaccurate, as all experience goes to show that it is wet-cold which is the principal agent in its production. Mr. Jocelyn Swan confirms the opinion of all alpinists when he states that in the Alps *frost-bite* sets in with the thaw, and Mr. C. Max Page, with an experience also of the Balkan campaigns, speaks of *frost* as being present in only 10 per cent of his cases. *Water-bite* has been suggested and is correct, but has an unfamiliar sound. The French expression in general use, *froidure*, has no obvious English translation. Prof. Delépine suggests *frigorism* or *subcalorism*, further distinguished as *general* and *local*, adding that the terms are intelligible, but would require the sanction of use. *Trench-foot* conveys no suggestion of cold, and is at best a descriptive makeshift. At present we see no alternative to its use, while adding *local frigorism* as a subtitle to this article.

Leather Investigation*

The Composition of Some Sole Leathers

By F. P. Veitch and J. S. Rogers

COMPOSITION OF NORMAL SOLE LEATHER.

VEGETABLE-TANNED leather is essentially a compound or mixture of hide or fibrous proteid material with tannin. Depending on the use to which it is to be put, it may be finished in several ways whereby the composition of the final product may differ greatly from the simple compound. The tanned leather may be used without material change in composition, as for shoe soles; it may be greased, as for harness and belting; or it may be greased and dyed, as for harness and shoe uppers.

In addition to the insoluble hide and tannin which are the essential constituents of leather, moisture, mineral matter, fats, and water-soluble tanning materials, which remain to a small extent in well-scoured leather, are present. All of these, when not present in excessive quantities, are proper and normal constituents of the leather. In fact, the presence of a large percentage of oils or fats, even in sole leather, is of decided advantage in increasing the water resistance, flexibility, softness, and life of the leather, while the presence of a small amount of uncombined tannin is often of some advantage in retarding water penetration and hardening of the leather and in making it solid and firm. The presence of a large excess of uncombined tannin materials other than those mentioned is useless or harmful.

Leather is not a definite compound and is therefore impossible to produce of an exact composition. The ratio of combined tannins to hide substances approximates 7 to 10, while the percentages of water-soluble constituents, mineral matter, fat, and moisture may vary considerably. Careful study of the analyses of well-tanned scoured leathers of various tannages, both American and foreign, warrants the conclusion that well-tanned, merchantable scoured sole leather of all tannages on analysis should give results on a moisture-free basis which fall between the following limits: Leather substance from 75 to 93 per cent, hides from 43 to 57 per cent, combined tannins from 31 to 42 per cent, water-soluble materials from 5 to 15 per cent, oils and fats from 1 to 6 per cent, ash from 0.25 to 1 per cent.

Well-tanned, honestly made leather should approach the upper rather than the lower limits for leather substance and oils and fats. The water-soluble constituents should consist only of the materials contained in the adhering tannin solution which have not been removed in scouring.

Properly air-dried sole leather should not contain, even in very damp weather, more than 20 per cent of moisture, and the average percentages for the year should fall below 15 per cent. Neither the ultimate buyer nor the shoe manufacturer should be called upon to pay for a greater average amount than this. It will be observed that the leathers reported herewith contain much less moisture, due largely to the fact that they are dried out very much after reaching the laboratory.

Normal vegetable-tanned sole and harness leather when burned should not leave more than 1 per cent of ash, and as a rule not more than 0.5 per cent. This ash is derived from the hide, from the lime used in unhairing, and from the salts usually dissolved in all waters. The magnesia of the ash when calculated to Epsom salts, $MgSO_4+7H_2O$, the form present in air-dried leather, should not exceed 1 per cent.

It is customary abroad to consider less than 2 per cent of glucose permissible, the assumption being that this amount may be present from the tanning materials. It is very doubtful if this amount of glucose is ever present in normal leathers from which the excess of tanning materials has been properly washed. Leathers on which the final liquors were sweet and exceptionally concentrated, and which are subsequently washed but little, may contain between 1 and 2 per cent of sugars, determined as dextrose.

The ether extract or fat may be as high as 5 per cent, probably never much less, to give pliability, water resistance, and durability to the leather.

WEIGHING OF LEATHER.

During an extended examination of sole leathers now in progress, it has been found that a surprisingly large percentage contains great quantities of foreign materials. Although it has long been known that some tanners make a practice of weighting or loading their leather, the extent of the practice is not appreciated outside the tanning and closely related industries. Tanners state that leather is loaded with foreign materials because the boot and shoe makers will buy only the lower priced leather, which, to use a trade expression, "cuts to advantage"; that is, from which the greatest number of soles can be cut at the lowest cost a pair. Many boot and shoe manufacturers claim that they use loaded leather because it cuts to better advantage than the same leather not loaded.

The character, value and wearing quality of leather varies with the part of the skin from which it is made. The skin from the upper part of the body and along the back is closer fibered than that from the lower part, under the body; it becomes more open textured, and consequently more porous as it passes from the backbone to the under side of the body. The skin over the posterior portion of the body is of closer texture than that over the forequarters; consequently the best leather is made from the hide in the region of the kidneys and hips, provided the skin is sound and not damaged in tanning. The leather from the "flanks" and "bellies" is more porous, lighter, and more flexible than that made from the "back," and in cutting the side of leather into soles the lighter and more flabby the lower portions the more of it is rejected. If, however, this lower portion has been stiffened and weighted with foreign material, no matter how useless it is nor how soon it may wash out, some shoe manufacturers will cut it into soles, thus obtaining more soles from a side. Because of these facts the shoe manufacturers calculate that weighted leather costs them less for each pair of soles than the unweighted leather.

Unloaded flabby leather makes poor shoe soles, and loading with materials readily soluble in water, as glucose and Epsom salts, increases the cost to the purchaser and does not make soles more serviceable.

Weighting Materials and Their Effects.—Loading or weighting materials are cheap. Those in most general use in this country are glucose, selling at 2 cents a pound, Epsom salts, or magnesium sulphate, selling at 1 cent a pound, and solutions of tanning or other organic materials, selling at 0.75 to 2 cents a pound. Barium sulphate and lead sulphate—generally formed by drumming the leather first in a solution of barium chloride, costing 2 cents a pound, or of sugar of lead at 9 cents a pound, and then in sulphuric acid—and sodium sulphate, costing 1 cent a pound, are also employed to a small extent. Of these loading materials, glucose, soluble organic materials containing little or no tannin, magnesium sulphate, barium sulphate, lead sulphate, and sodium sulphate are much more objectionable than a small excess of actual tanning material.

Loading with glucose, Epsom salts, barium sulphate, lead sulphate, excessive quantities of tanning materials, or with water-soluble organic material is often detrimental to leather. It is made hard, brittle, more likely to crack, and after the loading washes out, as usually happens quite readily except in the case of barium and lead sulphates, it is more easily penetrated by water. Loaded leathers are more expensive, less durable, and a menace to health. A distinction should possibly be made between the effects of an excess of true tannin and of other uncombined or loading matrials. The excess of true tannin may not itself be so objectionable, and may even be of temporary advantage, because the slowly soluble tannins make the leather more water resistant, and impede the removal of combined tannin from the leather.

Quantity of Added Weighting Materials.—The amounts of materials found in the loaded leathers examined are summarized as follows: Ash, from 0.2 to 2.7 per cent; ether extract, from 0.4 to 5.6 per cent; Epsom salts, from 0.2 to 7.5 per cent; glucose, from 0.2 to 12.4 per cent; water-soluble materials, from 13.4 to 34.3 per cent; water-soluble tannin, from 6.1 to 17.8 per cent.

If it is feasible to secure the lower figures, as it appears to be in a number of tanneries, the higher figures must represent very excessive quantities. A comparison of these with the figures given for normal leathers shows that the percentages of ash, Epsom salts, glucose, and water-soluble materials are, as a rule, above the permissible quantities, while the amounts of fats and oils and actual leather substances are lower than they should be. These figures show a serious moral, economic, and business condition. Approximately, 63 per cent of the leathers examined are weighted with glucose, Epsom salts, or both. This loading varies from 1 to 7.5, with an average of 3, per cent of Epsom salts, and up to 10.4, with an average of 5.5 per cent of glucose, and amounts to a total maximum loading, when both are present, of 16 per cent and an average of 8 per cent.

Waste of Materials in Weighting Sole Leather.—The tanners whose leathers have been examined produce a large percentage of the sole leather made in this country. It seems probable, therefore, that these samples are fairly representative of American sole leather, and if this be true fully 60 per cent of the sole leather is loaded with Epsom salts or glucose, or both, and practically all of it contains more uncombined tanning materials than it should.

If 60 per cent of the sole leather contains an average of 8 per cent of Epsom salts and glucose, at least 150,000,000 pounds have been weighted annually with no improvement in its wearing value. The people have paid for not less than 12,000,000 pounds of Epsom salts and glucose, plus a profit to the tanner for working them into the leather, and have obtained nothing of value thereby. The average amount of water-soluble material in these sole leathers is 23 per cent. Subtracting from this the average percentage of glucose and Epsom salts found gives the percentage of what for brevity may be called "uncombined tanning" materials, meaning the materials derived from the tanning liquors in which the leather was tanned.

The almost universal practice of weighting or loading with excessive quantities of uncombined tanning materials is perhaps the most reprehensible form of weighting. It is needless, and wastes valuable materials which can be employed in the production of more leather, and it often leads to bleaching or addition of glucose or Epsom salts to conceal the injury which frequently results from the presence of excessive quantities of uncombined tanning materials. The elimination of this waste would not only conserve our fast-diminishing native tanning materials, but reduce the quantity imported, and thus help maintain the balance of trade in favor of this country. It is an astonishing fact that practically all the leathers analyzed contain as much uncombined tanning as good quality oak or hemlock bark, and many contain much more. A table which is appended shows that approximately one third of the tannin in these leathers is uncombined, the quantity varying from 9 to 17 per cent. This is sufficient to tan one third as much sole leather as is now made. Fully half of this wasted tannin can and should be saved. It is worth approximately $1,000,000, and would tan approximately 100,000,000 pounds of leather. This tanning material is now practically a total loss.

For the past 15 or 20 years energetic efforts have been made to prepare from the waste liquors produced by making paper from wood by the sulphite process products that will tan hides. The woods from which paper-pulp is made, with but few exceptions, do not contain more than from 2 to 4 per cent of tannin. If this is all removed by the sulphite liquors which are subsequently concentrated to 50 per cent solids, the concentrated material offered for tanning purposes can contain at most but 4 or 5 per cent of tannin. Up to the present efforts to make leather with waste sulphite liquors have been crowned, at most, with but indifferent success, and in no case do the makers of these products from sulphite liquors advocate that they be used alone in tanning, but always in mixture with materials of known tanning value. These materials are now receiving careful attention from several sources for determining finally whether they have a proper place in the making of leather. Until such time as it shall have been shown that these products will make serviceable leather or that they contribute to the desirable qualities of leather they should not be used in commercial tanning.

Detection of Weighting.—Although it is not practicable for the ordinary individual to determine whether the leather in shoes has been weighted or loaded, the shoe manufacturer can do so in a very simple way. Large quantities of Epsom salts give leather the characteristic bitter taste of the salts, while glucose in quantity gives the leather a very faint sweetish taste.

Whether or not leather has been loaded with soluble materials can be readily determined by anyone by the

* *Bulletin No. 165,* U. S. Department of Agriculture, Bureau of Chemistry.

following simple procedure: Grind a sample of the leather (a pair of soles serves well) to a coarse powder in any convenient way. The leather may be rasped, cut with a chisel or shears, ground in a mill, or sawed. Weigh 100 grammes of the ground leather on a scale that will weigh accurately to 1 gramme. Place it in a small, dry, close-textured cotton bag which has been washed to remove the starch and other dressing material from the fabric and which has been given an identifying mark which will not wash out in hot water. Tie securely the mouth of the bag, weigh the bag and leather carefully, and record the weight. Place it in running water as hot as can be readily borne by the hand, and wash out the soluble materials by thorough kneading for 15 minutes. Squeeze out the water, and dry over the radiator or in any convenient way until the leather is perfectly dry. Cool and weigh again. The loss in weight represents the amount of soluble matter which has been washed out. This loss in grammes as thus determined directly represents also the percentage loss, and if this exceeds 15 per cent the leather may safely be said to be weighted.

The following figures show some results actually obtained by this method and also the results obtained in careful analysis of the leather:

WATER-SOLUBLE MATERIAL IN LEATHER.

Sample No.	Regular analysis. Per cent.	Washed out in 10 minutes. Per cent.	Washed out in 20 minutes. Per cent.
2119	25	20	20
2127	28	24	24
2130	32	34	34
2134	25	24	24

For practical purposes the results obtained in this way are sufficiently accurate.

BLEACHING OF SOLE LEATHER.

Leather which has been properly tanned with liquors made from chestnut or rock oak bark has been considered for generations to be the best for shoe soles. This leather has a bright light-oak color, the price it brings depending very largely on this brightness and uniformity of color. As it comes from the tanning liquor leather is often quite irregular in coloring, and when made from nearly all other vegetable tanning materials it is darker in color than that tanned with oak bark. Irregularity of color is not necessarily a sign of inferiority, but, as a matter of fact, it generally indicates damage done in the preparation, tanning, or finishing of the leather, or stained or damaged places on the original hides. The shoe manufacturer knowing that uniform color is characteristic of hides properly prepared, tanned, and finished, and that oak bark makes a bright-colored leather, demands light uniformly colored sole leather. The wearer of shoes also prefers leather with a good clear, even color.

To secure the higher price which this much-desired uniformity, brightness of color, and the appearance of oak-tanned leather brings, the leather is bleached. Solutions of soda and sulphuric acid applied successively, oxalic acid, or oxalic acid and tin chloride, are the chemicals with which this is usually done. The treatment removes some of the excess tanning material from the surface and gives the leather a much lighter color. Bleaching is especially detrimental, as the sulphuric acid is rarely completely neutralized, and consequently greatly hastens the rotting of the leather. The cost of the leather is increased by this procedure, the servicabiliy of the leather is decreased, and the superior appearance secured in this way permits the fraudulent sale of the leather at a higher price. The bleaching of heavy leather is the most useless and harmful of all leather-making practices, and the most vigorous efforts should be made to eliminate it.

MISBRANDING OF LEATHER.

Formerly all sole leather made in this country was tanned with oak or hemlock bark, or a mixture of the two, and the leather so tanned was known as oak, hemlock, and union (oak and hemlock) respectively. More leather is tanned now with quebracho than with oak, and more with quebracho, mangrove, myorobalan, gamber, and chestnut collectively than with hemlock. Nearly half of the vegetable-tanned leather made in this country is tanned with materials other than oak and hemlock bark. Nevertheless, practically all vegetable-tanned leathers are still termed, oak, hemlock, or union.

Many of the leathers are misbranded as to tannage. The tannin-free water extract from a leather tanned with chestnut oak is fluorescent when made faintly alkaline. It will be seen that the water-solubles from some of the so-called oak leathers are not fluorescent; these leathers were not tanned with chestnut oak. The figures for water-soluble materials also show that many of these leathers were tanned with tanning materials other than oak or hemlock bark. Tanning liquors made from nearly all materials now used in this country, such as oak, hemlock, and mangrove barks, chestnut and gambier extracts, and myrobalan, contain approximately 2 parts of tannin to 1 part of non-tannin, not including in the non-tannin the sugars which the materials contain, which are fermented to acids, and do not, therefore, add directly to the weight of the leather. Quebracho extract, on the other hand, contains approximately 7 parts of tannin to 1 part of non-tannin.

In the last stages of tanning the leather is in contact with practically fresh normal liquors in which the relations just stated hold, therefore the tannins and non-tannins of the water-soluble extracts from leather will tend to approximate the same ratio to each other as the liquors in which it was tanned. If the sum of glucose and magnesium sulphate is subtracted from the figures for the non-tannins in any particular leather, the difference approximates the non-tannin figures for the liquor in which the final tanning of the leather was conducted. A comparison of this figure with the figures for soluble tannin shows the ratio of tannin to non-tannin in the liquor, and in many instances proves conclusively that tanning materials other than oak or hemlock bark were used; in fact, the ratio indicates that quebracho was used, but no intimation of the fact is given in the branding of the leather. The branding of all leathers—"oak," "hemlock," or "union" —is deceptive, and the practice should be discontinued. No leather should be branded oak, hemlock, or union which is not tanned entirely with oak or hemlock, or a mixture of the two.

The misbranding of leather is indicated by the recent census statistics. The percentage of oak leather reported in 1909 is 7 per cent greater than in 1904, the percentage of union leather is 32 per cent greater in 1909 than in 1904, while the quantity of hemlock and oak barks and extracts used in 1909 is materially less than in 1904.

PREVENTION OF WEIGHTING AND BLEACHING.

It is improbable that the present practices of weighting and bleaching sole leather will be voluntarily discontinued by the tanner. Intelligent buying on the part of the public will do much to break up these practices. The individual purchaser, of course, cannot know whether the leather in the shoes he buys is weighted or has been bleached, but if he will insist that they shall not be made of weighted or bleached leather, and will not buy from those manufacturers who make such leather, the quantity of leather so treated will materially decrease, and it will be found that shoes are more durable and consequently less expensive.

The weighting and bleaching of leather may be easily and absolutely controlled by concerted action on the part of the shoe manufacturers. It is very simple for them to determine whether the sole leather delivered is weighted, and if they will refuse to buy such leather it will not be made. Shoe manufacturers will see to it that sole leather is not weighted if the public will take sufficient interest in the matter to demand unweighted leather.

Cast Iron for Explosive Shells

CONSIDERABLE attention, says *The London Daily Telegraph*, has be n devoted recently to the proposal that cast iron should be substituted for steel in the manufacture of shells for war purposes.

At first sight the suggestion may appear very attractive. Shells made of cast iron, which is cheap, are to be produced in a single operation by casting in the foundry. They are to take the place of steel, which is dear, and which is fashioned by tedious and expensive mechanical processes. But the question is by no means so simple or so one-sided as has been represented.

It is well known that until the Crimean war all large projectiles and the majority of large guns were made of cast iron. With the introduction of rifled cannon came elongated projectiles, and ultimately the immense range, accuracy of aim, and penetrating power of modern ordnance.

Before the introduction of nickel steel for armor-plates, and the hardening of the surface of such plates, cast-iron shells were used for penetration with good effect. They were made of cold-blast pig iron, of the same composition as is still used for chilled rolls. The heads of the shells were rendered extremely hard by "chilling" during the process of casting. Such metal was, however, quite unable to penetrate modern armor-plate, and this deficiency in power to resist destruction by shock led to the abandonment of cast iron for such purposes.

Cast-iron shells, even if made of the best qualities of pig iron, would undoubtedly be much cheaper than chrome steel, armor-piercing shells. But since they cannot do the same work any comparison in cost for such purposes is out of the question. If cast iron is to be used for shells it will only replace steel for some, not for all, purposes.

Cast-iron shells were regularly supplied to the British government before the war, and were used for practice by the army and navy. For such purposes they are doubtless well suited; but the question arises: Is there any considerable opening for shells made of cast iron in present hostilities? There is good evidence that the Germans have used cast-iron shells on various occasions; it is suggested that in so doing they were using up old stock, and this was taken as evidence that the enemy was short of munitions. With such a suggestion we should not agree; it is highly improbable that shells made some twenty years ago or more would be suitable for modern calibers, or filled with suitable explosives. It is much more likely that these cast-iron shells have been deliberately made as part of modern equipment.

In comparing the prices of iron and steel it may be pointed out that the special quality of cast iron used for chilling purposes is no longer necessary if shells are not to be used for penetration, as is the case in the trench warfare of to-day. Hence, instead of paying £6 per ton, a mixture could be used which would give soft, sound, uniform castings, and which at ordinary times need not cost above £2 10s. per ton.

The steel used by our government for high explosive shells is of superior quality, with sulphur and phosphorus not exceeding 0.04 per cent, and thus would cost, in the crude form, twice or three times as much as the cast iron. But after all, the cost of this crude material is relatively very small as compared with the finished article. If steel is better, for all purposes, the cost at this stage practically does not count. There is, however, evidence that the steel of the German shells, used in the East coast raids, was of inferior quality, so far as phosphorus is concerned; but the metal was strengthened by the addition of other elements. It was steel such as could be made cheaply in large masses; but it was certainly not lacking in destructive effect.

For such purposes, therefore, we may compare cast iron at say £2 10s. per ton with a cheap steel at not more than twice this cost. The question of the ultimate cost of the crude material would then become almost negligible, as compared with the work which has to be put upon it, and the cost of the explosive, fuses, and so forth. When treated in large masses steel can be cheaply rolled into rods of suitable size, and these, by means of automatic machinery, can be converted into the smaller shells at a price which leaves little margin for casting when dealing with these sizes.

There are, however, advantages which can reasonably be claimed for the use of cast iron for shells of a suitable size. From a military point of view, a great advantage possessed by cast iron is stated to be that this metal breaks into a number of smaller pieces, and is, therefore, more destructive when used against hostile troops.

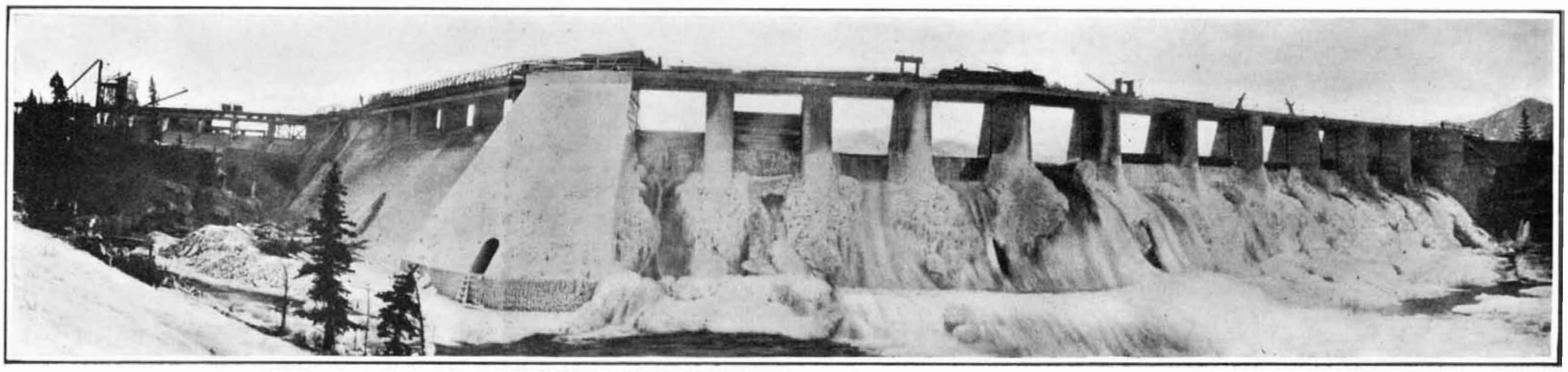
Whether this claim can be substantiated or not, there remain many commercial advantages which are worthy of consideration. The use of cast iron would render available for war purposes a class of iron which is largely made in the United Kingdom from native ores. It would, therefore, enable our supplies to be extended in a most beneficent manner. The castings would be made in foundries which are at present contributing comparatively little to the nation's resources, and turn a considerable number of new hands on to munition work. The skill and training of our foundrymen are ample for this kind of work, and it could be immediately put in hand. If an adequate demand were assured it would pay to install up-to-date molding machines and appliances. The soft iron above recommended could be turned and machined in the subsequent operations as readily as, or even more quickly than, steel; while sound uniform castings could be regularly anticipated.

If it be found that there are no military disadvantages, the proposed change would, therefore, greatly increase our resources, cheapen our product, and extend employment to a class of men who have hitherto been able to do but little to aid in the supply of munitions.

A Wide and Narrow Gage Railway Comparison

IT is generally known that the proportion of the weight of a train to that of the load carried is surprisingly great, but that the proportion is much more favorable in the case of a narrow gage than in a wide gage road is not generally appreciated. A striking comparison that illustrates this point is contained in the following item from *The Engineer*.

To convey 26 officers and 759 foot soldiers, together with their luggage, two trains of twenty vehicles each, and weighing 325 tons, were required for the 3-foot 6-inch gage railways of Queensland, but the same number of men required two trains of nineteen vehicles each, but weighing 495 tons, on the 4-foot 8½-inch gage railways in New South Wales. For 536 officers and men, 563 horses, 24 road vehicles, and accompanying baggage, five trains weighing 981 tons were required in Queensland, but the five trains for the same number of men in New South Wales weighed 1,285 tons.



Kananaskis dam for development of electric power.

Water Powers of Canada

Notes of the Natural Resources and Some of the Developments

According to government investigation the available water powers of Canada amount to 17,000,000 horse-power, of which 5,600,000 horse-power is in Quebec Province.

The sources of water power of immediate importance and interest in Quebec Province are those within easy reach of the Ottawa, Montreal, Three Rivers and Quebec districts.

The principal water powers in the Ottawa district are those of the Ottawa River and a number of its tributaries. The Quinze River, really an upper portion of the Ottawa River and flowing near the Cobalt mining district, has an available power of 90,00 horse-power, no part of which is developed at present. The Lievre River, a principal tributary of the Ottawa River, has a total available horse-power estimated at 85,000, of which less than 10,000 horse-power is developed. The Gatineau River, a still larger tributary of the Ottawa River, is capable of generating 225,000 horse-power, none of which is utilized to date.

On account of their near proximity to Montreal the Carillon Rapids on the Ottawa River are of exceptional importance. These rapids are capable of developing 160,000 horse-power. Because of the ready power market existing in the Montreal district, water power development has been carried out extensively in that section, the only large water powers in the district being on the St. Lawrence River. The Cedar and Cascade Rapids, situated on the St. Lawrence about 35 miles from Montreal, and having a fall of 30 feet, are capable of generating 800,000 horse-power.

It is stated that the present development when completed will have an output of 180,000 horse-power. To date there are nine vertical turbine units installed, each developing 10,000 horse-power, 60,000 horse-power of which is transmitted to aluminium works at Messina, and the remainder to Montreal. The present plans of the Canadian Light, Heat and Power Company, at St. Timothes, furnishes about 20,000 horse-power to Montreal. When completed the plant will have a capacity of 50,000 kilowatts. About 13,000 horse-power is furnished to the Montreal consumer by a development on the Soulanges Canal, near Cedar Rapids. The Lachine Rapids, on the St. Lawrence River, have a total available horse-power estimated at 400,000. At present only 13,000 horse-power has been developed. At Chambly, a hydro-electric plant on the Richelieu River provides Montreal with 20,000 horse-power.

It is claimed that Montreal at the present day receives an aggregate of 126,000 horse-power supplied by falling water. Of the still available power around Montreal, 240,000 horse-power can be easily developed as the market demands.

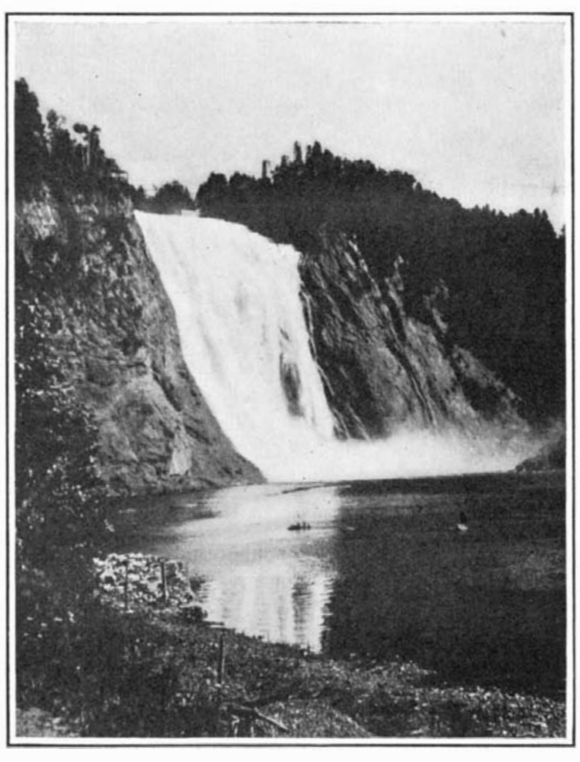
It is of interest to note that in the Three Rivers district the St. Maurice River flows for a distance of 300 miles through richly timbered areas, ending its course at the city of Three Rivers. The pending construction of a new dam on the St. Maurice River at a cost of $1,500,000 to regulate the flow of water will render this river capable of developing 550,000 horse-power. The most southerly water power on the St. Maurice is situated at Le Gres Falls, where 60,000 horse-power is available, none of which has been developed.

The celebrated Shawinigan Falls, 21 miles from Three Rivers, is the scene of the next hydro-electric plant on the river. The entire water rights of Shawinigan Falls are owned by the Shawinigan Water and Power Company, which sells a portion of the water to local manufacturing concerns for their own use, and operates its own large power plant with the remainder. This plant is capable of generating 155,000 horse-power. Some of this power is used at Shawinigan Falls for the reduction of aluminium, the manufacture of carbide, cotton and other goods; but the larger portion is transmitted to Montreal, Three Rivers, and various smaller towns, factories and mines in the district.

Grand Mere Falls, on the St. Maurice, 12 miles above Shawinigan Falls, has a head of 75 feet. At present 30,000 horse-power is consumed in the manufacture of paper. The available power at Grand Mere amounts to 100,000 horse-power. At La Tuque, on the St. Maurice, about 103 miles from Three Rivers, there is a 70-foot waterfall, capable of developing over 75,000 horse-power.

The existing pulp mills at La Tuque consume only 3,500 horse-power. There are a number of water powers north of La Tuque which still belong to the Crown, and are available for future development.

In the Quebec district, although a vast amount of water power is available in the region directly north of Quebec city, a comparatively small quantity has been developed to date. The larger water powers in this district are practically all to be found upon rivers flowing to or from Lake St. John, and especially upon the Saguenay River, which connects Lake St. John with the St. Lawrence. At Grand Discharge, where the lake empties its waters into the Saguenay, there are two main falls which are capable of generating 375,000 horse-power, and the water rights have been secured by the Quebec Development Company, which has in view a storage scheme whereby the above available power would be increased to over 1,000,000 horse-power.



Montmorency Falls, near Quebec.

It is maintained that construction work on this development is expected to commence in the near future. Some 20 miles below Grand Discharge is a series of rapids having an available power of over 240,000 horse-power, none of which is yet developed. At Chicoutimi, a few miles farther down the Saguenay, a hydro-electric plant is developing 7,500 horse-power which represents about half the available power. Among the chief tributaries of the Saguenay are the Shipsaw River with 8,000 available horse-power, some of which is being developed, and the Perabonka River with 120,000 horse-power available. A number of tributaries of Lake St. John, flowing from all directions, have their courses broken by numerous falls and rapids, which might be turned to great industrial use.

It is of interest to note that of those rivers running into Lake St. John, are the Ashwapmuchuan River, with 250,000 horse-power available, the Mistassini and Muskosibi Rivers, each with 12,000 horse-power, the Metabetchouan River, with 11,000 available horse-power, and the Quiatchouan River, whose falls are capable of generating 13,000 horse-power, of which 5,000 horse-power is already developed. A vast amount of power is available in the Lake St. John region, most of which could be transmitted electrically to Quebec city, if desired, or used on the spot for electro-chemical processes and other purposes.

There are many miscellaneous powers in the Province of Quebec. On the north shore of the St. Lawrence, between the Saguenay and the Atlantic Ocean, the country is scattered with large water powers, which, like the country itself, are entirely undeveloped. On the south shore of the St. Lawrence east of Quebec, the only power rivers are River de Loup, and Magdalen River, of which the available power is 3,500 and 50,000 horse-power respectively. It is estimated that nearly 1,000,000 horse-power is available on the rivers scattered on the James Bay slope. The developed water power in the Province of Quebec amounted at the beginning of 1915 to approximately 520,000 horse-power, representing less than 10 per cent of that available.

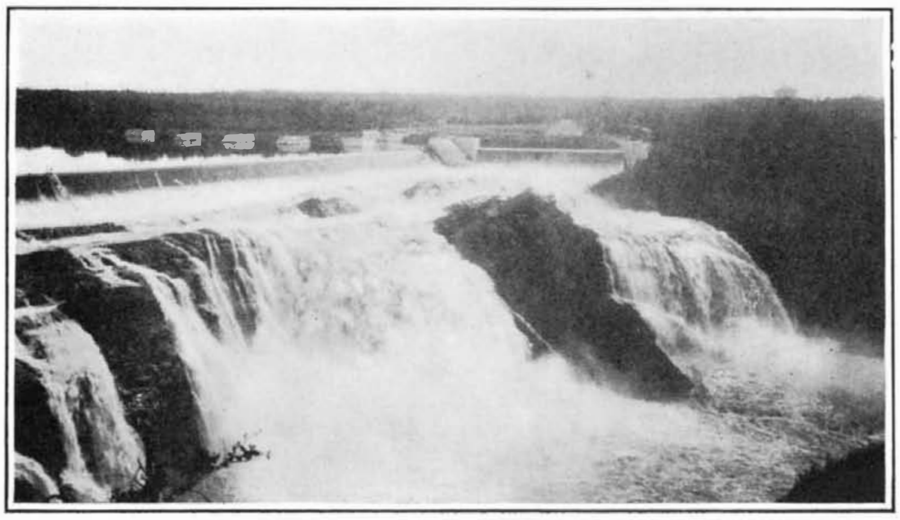
THE PRAIRIE PROVINCES.

The Eau Clair plant was the first hydro-electric development on the Bow River, and was carried out by the Eau Clair Lumber Company, within the city limits of Calgary. While the initial type of construction used for development was not of the most permanent character, the possibilities are excellent for the construction of a very efficient plant at this point, utilizing the present head of 12 feet. The present capacity is 600 horse-power, which is used for lighting under a city franchise.

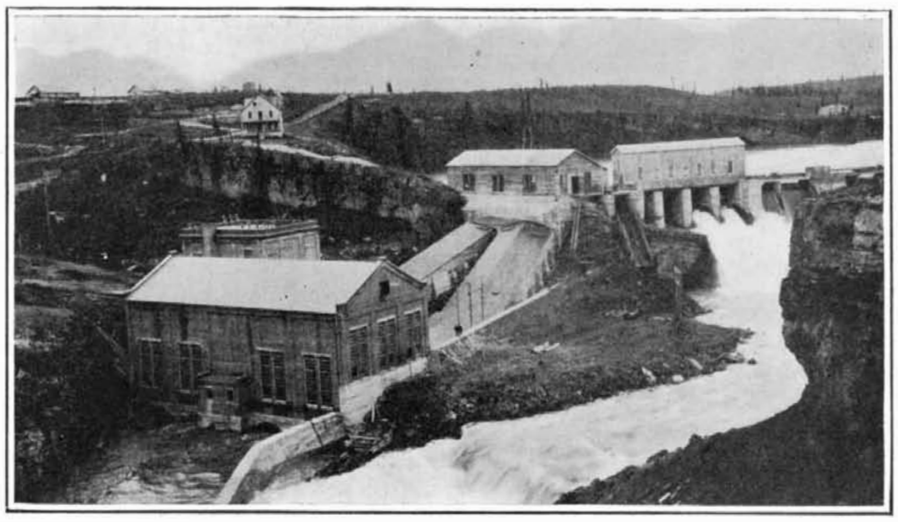
The Horseshoe Falls plant is located about 50 miles west of Calgary, and at this site is one of the very few concentrated falls to be found upon the Bow River. The Bow River, at the Horseshoe Falls, flows through a deep gorge, the walls and bed of which are formed of a shale banded with sandstone. At this point a massive outcropping of inclined rock intervenes, and as time passed a channel was eroded through this natural dam and a fall of some 25 feet occurred. A solid concrete dam has been built across the gorge on the lip of this outcrop, and this, with the natural fall, produces a head of 70 feet.

The complete power equipment consists of four turbines, two being of 3,750 horse-power capacity and two being of 6,000 horse-power capacity, each. The electric generators are direct connected and produce their power at 12,000 volts, this being stepped up by transformers to 55,000 volts for transmission to Calgary. A portion of the power is transmitted to Exshaw for use in cement mills direct at the generator voltage of 12,000 volts. The transmission lines, in duplicate, are of aluminium cable on wooden poles.

The hydro-electric development at the Kananaskis Falls is immediately below the junction of the Kananaskis and Bow Rivers, and about 2 miles above the Horseshoe Falls. The head is composed of rapids and a series of three falls, giving a total drop of approximately 55 feet. Above the rapids, the Bow is wide and fairly shallow, while the banks are comparatively low, but gradually increasing in height to the head of the falls. Below the falls the banks are perpendicular, the river flowing through a rather wide canyon. The banks of the Kananaskis are high, the west bank being perpendicular and rising at least 40 feet above the surface of the stream: the slope of the east bank is more gradual for the first



Dam and falls on the Chaudière River, Province of Quebec.



Horseshoe Falls and power development at Calgary.

few hundred yards, but after that it is high and abrupt.

The development adopted includes a dam placed across the head of the falls, raising the water and diverting it into a canal excavated on the south side of the river, which conveys it to the intake. The water from the intake is conveyed in tunnels to the turbines in the power station, which are of single runner type, with vertical shaft, and utilize the created head of 70 feet. The turbines are at present two in number, each of 5,800 horse-power capacity, direct connected to a generator. The voltages of 12,000 on the generator and 55,000 volts on the transmission line correspond to the characteristics of the electrical output of the Horseshoe Falls plant, to which it may be connected to operate in parallel, the two plants being owned and operated by the same company to serve the same markets.

The Bow Fort site is located about 4 miles below Horseshoe Falls at the foot of a number of rapids and swifts which aggregate 70 feet of fall below the tailwater of the Calgary Power Company. The site available for the dam is excellent, and a head of 66 feet may be created by the dam, allowing 2 feet leeway for operation of the Calgary Power Company's tailwater. Over 12,000 horse-power are available here.

From Bow Lake, the source of the river, down to Laggan, the river flows for the most part through a wide valley in the midst of towering mountains. Below Laggan, as far as Kananaskis Falls, the valley traversed is wide, flat and the stream is tortuous in its course.

The storage section of the Bow River, a stretch of approximately 90 miles in length, lies to the west of Kananaskis Falls, and entirely in the mountains. Nearly all the streams flowing into the Bow River have, at or near their source, a lake of greater or less size. The larger lakes include the Bow and Hector Lakes at the highest elevations; Lake Minnewanka, near Banff, at the head of the Cascade River; the Spray Lakes at the head of the Spray River; and at the headwaters of the Kananaskis River, Kananaskis Lake. Other lakes which are extremely valuable for their regulating effect, but not so suitable as controlled storage basins, include Lake Louise at Laggan, Ptarmigan, Baker and Redoubt Lakes, Moraine Lake, in the valley of the Ten Peaks.

The mean flow for the winter months has been 720 cubic feet per second, but by means of the storage that has been and may be created, it is anticipated that the mean flow can be increased to about 1,500 cubic feet per second. The effect of such storage upon the power output is to raise the winter mean output of 19,785 horse-power on six sites available, to 48,175 horse-power, and in addition a plant to be constructed on the Cascade River and supplied by water in transit from the Minnewanka storage lake would be capable of producing 1,165 horse-power. The Minnewanka storage system is now complete and includes a dam at the head of the Cascade River.

It is claimed that within the provinces of the Dominion of Canada and excluding the Northwest Territories, practically all of the Yukon, and the northern and eastern portion of Quebec, it is estimated that 17,764,000 horse-power is available, this amount being inclusive, in the case of Niagara Falls, Fort Frances and the St. Mary's River at Sault Ste. Marie, of only the development permitted by international treaties, and further does not contemplate the full possibilities of storage for the improvement of capacities. The developed powers which are inclusive of all water powers, whether for electrical production, pulp grinders, for milling, or for the great many other uses, aggregate 1,711,188 horse-power.

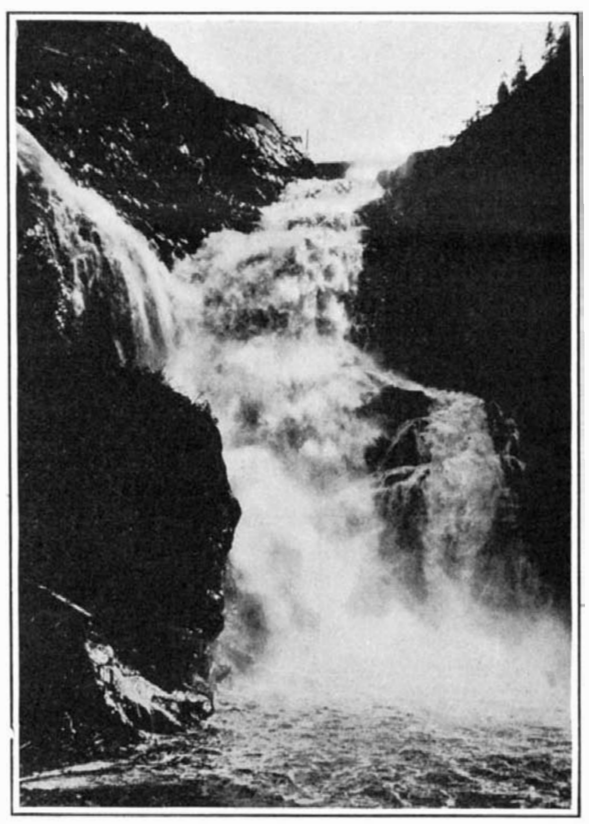
The prairie provinces are essentially agricultural, but a very large amount of electric power will undoubtedly be utilized.

The water powers of Manitoba, Saskatchewan, Alberta, the Northwest Territories and the Yukon, are under control of the Dominion Government. The Dominion Government water power policy as administered by the Water Power Branch of the Department of the Interior, affords every reasonable protection to the public as to rentals, periodic revisions, control of rates and limited grants, and at the same time fosters legitimate private enterprise to return reasonable profits while the regulations in force afford all possible assistance to the development of water powers which have reasonable assurance of economic utilization.

Tortoise-Shell Divination

By Nobitake Tsuda, (Expert in the Imperial Museum Tokyo)

THE importance of this practice in Japanese eyes may be inferred from the fact that when the Imperial Commissioners for the Coronation were desirous of finding with unerring wisdom the best plot to choose on which to grow the rice for the great occasion they resorted to tortoise-shell divination. This rice is offered to the ancestral gods during the Diajosai ceremony, and it must be grown on land approved of by these divinities. To ascertain just what paddyfield the gods have selected was determined in the manner suggested. The practice has been followed in Japan from time immemorial.



Quiatchouan Falls, Province of Quebec.

The practice is not, of course, limited to Coronation times; it is often used in connection with other Imperial functions. It has, indeed, a long history, and is said to have originated in China. In the early days of the Japanese Empire civil and religious functions were often performed by the same officials; the government officer was a priest. In later times the two functions were separated and an order of priests appeared. There remained, however, a Department of State for the management of religion, which had some twenty officials, whose chief duty was to ascertain the will of the gods by what is known as tortoise-shell divination, which is said to have been introduced into Japan about the third century.

When the Empress Jingo subjugated Korea she sent there a governor named Ikatsu-no-omi; and during his stay there that official became conversant with the tortoise-shell system of divination; and upon his return to Japan he was accustomed to give his services in the art.

The way of carrying out the ceremony is interesting. Before the divination can be effected a god called *Urbanokami*, which means the god of the divination yard, is worshiped by the diviners after bodily purification. They then take a tortoise-shell, the inside of which must be scraped to get it quite thin, at least about a quarter of an inch in thickness, after which the outer surface has to be polished as smooth as a mirror. In the shell several hollow squares are carved, inside each of which a certain sign is marked in black ink, the marks being put under great heat, making cracks on the surface; and then the cracks are studied in accordance with the formula in the divination book; the gods send a code message, as it were.

It is now known that this was not the earliest form of divination known in Japan; for there was a kind called *Futomani*, in which the shoulder-blade of a stag was used in place of a tortoise-shell. It reminds one of the habit in some countries of foretelling the degree of snow by the shades on the breast bone of a goose. The *futomani* method is referred to in Japanese mythology. According to the *Kojiki*, which is one of the oldest examples of Japanese literature extant, when the gods Izanagi and Izanami went to heaven to take counsel with the greater gods as regards the mistakes they had made in the work of creation the superior divinities taught them how to ascertain the will of Heaven on earth by using the stag's shoulder-blade. This is probably the earliest mention of divination in Japanese records. The *futomani* was no doubt practised until the tortoise-shell method came in as an improvement from China in the days when the Japanese were, as to-day, worshiping all things foreign. According to the *futomani* method the shoulder-blade of the stag was put over a fire and the cracks thus caused were compared with a set of diagrams used for interpreting the will of the gods. While some think that this method was indigenous to Japan, I am convinced that it, too, came from China.

An excavation suggesting Chinese origin was made some years ago in Honan, when various bones were unearthed, including not only tortoise-shell, but stag bones, and even ox and horse bones, all bearing traces of having been subjected to heat, proving that they had been used for divination. Some of them bore hieroglyphics recording the message obtained, the meaning of which cannot now be deciphered. Some are of the opinion that these relics date back beyond the time of Confucius; but that is a matter difficult to divine. They are, however, certainly not later than the Han dynasty, that is, two thousand years ago.

From the opinions of experts it may be said that tortoise-shell divination was a regular practice in China, the common people using other and more common bones. According to Chinese faith the tortoise was a sacred animal, living, as they believed, thousands of years, and, therefore, having the longest of all living experiences. The judgment obtained from its shell was thought to be superhuman. Thus for the sake of tradition and the honor of the nation's ancestors the old practice was used in connection with the Imperial Coronation, which, if it can do no good, certainly can do no harm, reminding us of how vastly we have changed, if teaching no other lesson. It also suggests that somehow man is not supremely wise, but still dependent on the wisdom of Heaven to prevent his making mistakes. Methods of approaching Heaven may be so different as to cause one set of petitioners to pooh-pooh the methods of the others, but the necessity of making such approach is never doubted by either party.—*Japan Magazine.*

Bacteriology of Wounds in War*

Complications That Have Resulted from Special Conditions

CONDITIONS in France are not favorable for researches in pure science, and besides almost all the laboratories are closed and the assistants are with the armies. But they have not been slow to realize the value, the necessity indeed, of having bacteriological work in the multiple and complex questions of hygiene and outbreaks. Little by little there have been organized at the front even, groups of research men, kaleidoscopic according to the chances of coming together, but available from their theoretical and practical knowledge. They have attacked the problems that are urgent and of immediate interest and immediate use.

It is not the purpose here to speak of the immense service accomplished by such men in the suppression of epidemics by means of laboratories often improvised, usually imperfectly equipped and not infrequently established at some kilometers distance in front of the regular medical stations, but of activities in other specialties, particularly the infection of wounds and how to prevent or neutralize this. The list of such accomplishments is already very long, and it is impracticable to include everything, but the notes following are according to the observations of a single authority and in the divisions of the armies that he personally has had occasion to visit.

The first group of wounded, observed in Belgium in August of last year, were almost all of them struck by the bullets of machine guns. Many of them recovered rapidly without suppuration, and the wounds closed by first intention, as the medical phrase expresses it. The experience of the writer here was so encouraging that inadvertently he termed the missiles "humane bullets," but, alas, they were humane for a short time only.

Those who were first wounded had come from the chimney corner; they were men, young, well, not yet fatigued, whose clothing and whose bodies were clean. They were struck by bullets from a long distance, and these various conditions tended to keep at the minimum the number of septic wounds. After the battle of the Marne the aspect of these wounds was changed. Men were then fatigued by long marches, their clothing was dirty from contact with the ground, and attention was often delayed. The number of clean wounds diminished rapidly, and there then appeared a sad procession of infections, often serious ones, abscesses, gangrene, septicemia, etc.

Then the trenches afforded a great number in addition of suppurating wounds. Although the care for cleanliness in the camps and the good quality of the first aid and the rapidity with which it could be applied were valuable in diminishing the number of grave infections, there were causes of increase in the soiling of the soldiers' clothes and the multiplicity of wounds from shrapnel or bursting shells. Happily as the war has progressed means have been found to ameliorate some of the dangers of the latter.

The Balkan war had already led the way to the same facts. Dr. Laurent, of Brussels, had already related in *La Nature*, No. 2119, his experiences during eleven months of campaign. He had set forth that wounds from bullets were less likely to become infected than those from the explosive projectiles, in the ratio of from five to twenty-eight per cent as against forty per cent. He noted also that as the war progressed the ratio of wounds badly infected decreased and that wounds in the legs were more likely to be infected by about one-fifth. This he attributed to the dirtier trousers and boots and neglect of personal cleanliness.

The ball from the gun is generally aseptic in consequence of the high temperature to which it is subjected in firing, but it is not sufficiently hot when it reaches the enemy to sterilize its passage through a body. Now it can infect the wound by taking into the latter bits of clothing, like cloth or leather, with whatever their bacterial burden may be, or it can carry in contaminated skin from the exterior of the wounded man, and lodge them in the intestines, respiratory organs, digestive tract, or elsewhere.

On the other hand, the projectiles from cannon, of smaller size and with weaker velocity, produce most often infected wounds. Every projectile that has touched the earth becomes a carrier of dirt, and such missiles account for much of the tetanus. Added to this there is the general health of the wounded one, his fatigue and his resistance, that are factors in favor of or against recovery. Then there is the quality of the attention, which is another important factor. On these points in general the practical experiences of the war has shed a great deal of valuable light.

* Translated from *La Nature* for the SCIENTIFIC AMERICAN SUPPLEMENT.

It is next desirable to explain somewhat the mechanism of infection and the methods taken to guard against it or to prevent it. Two French physicians, Policard and Phélip, have been able to make observations of the phenomena following shot wounds from the first to the thirtieth hour, and have presented their results in a paper in the *Press Médicale*. These researches were pursued in an ambulance at the front while under bombardment, and have included instant examinations with the microscope of the flesh of wounds under treatment.

In a general way the simile of soldier-laborers may be used to describe the process of repairing injuries. The blood carries leucocytes or white corpuscles which at one and the same time can repair injury and can destroy microbes by absorbing them, a wonderful amount of this destructive work of germs being possible to an active corpuscle.

In a general way up to the fifth hour after injury there was no phenomenon of reaction on the part of the tissues or the blood corpuscles, but from the fifth to the ninth hour there was considerable activity on the part of both these agencies and others of the great number of active items that physicians find in the blood. This is a defensive action against the injury, but it is so far characterized rather by its weakness. From the ninth and the tenth hour the dominant phenomenon is the growth of the microbes, germs such as *Bacillus perfringens*, the microbe of gaseous gangrene, all of them bacteria, begin to develop along the foreign bodies that have been introduced into the wound, first into the coagulation of blood that forms and then beyond it into the injured tissues. From the twelfth to the twentieth hour there are two concurrent processes, on the one side the multiplication of the organisms, bacilli (rod-like forms) and cocci (round forms), and at the same time the secretion by these of toxins of great activity, while the counter reactions of the tissues are always much less intense. Till the thirtieth to the thirty-sixth hours there are the contrasted strengths of these opposed operations. By that time the patient will certainly arrive in the regular hospital.

From the facts secured in observations of such character, certain orders of procedure by the physicians may be outlined. One is the absolute necessity of the most careful cleansing of the wound, so as to remove every particle of clothing or other introduced substance, while the other is the rational and discrete employment of antiseptics, which should be of such character as to cleanse and at the same time to interfere as little as possible with the already weak reactions of the tissues.

As soon as the patient arrives at the hospital in the rear, his infection already established, the duty of the physician is to combat it and to cause the cessation of the flow of pus.

But if the projectile remains imbedded in the flesh, an examination with the X-ray will show it, locate it and give the facts permitting its most easy extraction. If the wound is shallow the bits of foreign substance may be withdrawn, and also the foci about which suppuration is likely to be developed. But if the wound is deep or in a place where any operation is serious, the methods of the laboratory will help the surgeon and will suggest perhaps means of treatment.

The most simple of the bacteriological aids is the examination of the pus, which may be done with the microscope and by bacterial culture. The first is likely to indicate the micro-organisms concerned in the suppuration, but it is hardly sufficient to the needs. One reason for further investigation is that even well-related bacteria may not be a constant sign, and that they do not always produce the sores or appearances that are characteristic to them. These conditions arise because the pus is not related alone to the germ, but also to the cells of the man, and, as in any other process of growing, the grain depends both on seed and soil.

To take count of both the factors in an infected wound the experts have recourse to what bacteriologists term the opposite index. In 1902 Wright, an English physician, proved that the blood contains substances which serve to prepare the food of the white corpuscles or leucocytes, which, after having absorbed food, are called phagocytes. This terminology may be compared with the name, man, for the male human, and warrior, after he has been in battle. How the opsonins prepare the morsels for the leucocytes does not matter here, but it is true that the amount of opsonins in the blood may be determined for any individual, and when expressed it is called his opsonic index. The determination of the opsonic index is now a well-known process among physicians and bacteriologists.

Wright's immediate application of his discovery was to typhoid fever, but before the war it was used for diagnosis in tuberculosis, cerebro-spinal meninigitis and other diseases, the index serving to show as often as the physician might desire the precise condition of the day's fight in the patient's blood. Since the war began this method has been used to determine the seriousness of suppuration of wounds.

Recently, in the *Presse Médicale* of July, 1915, Dr. Delbet has devised another method of arriving at the same knowledge, to which he has given the name "pyoculture." In his theory Dr. Delbet realizes that in the struggle between the man's organism and the microbe there are not only the factors of the man's resistance and the virulence of the microbe, but that there are local conditions which will vary the resistance in different places in the body. For his determinations this expert uses not only cultures of the blood and the tissues, but of the pus itself.

If the wound is a grave one the preliminary examination with the microscope will usually be sufficient, for the enormous number of bacteria will be striking, and it will not be necessary to wait for a full series of pyoculture tests to know what to do. The indications are very direct; they are, so to speak, bulletins from the wounded man's internal field of battle.

There are a number of things which may be deduced in the course of this procedure. Certain numerical relationships between the bacteria of the pus and of the blood or tissues will indicate that the struggle is a serious one; other relationships suggest that the patient is fighting well, but should have all the aid that therapy can give him; while a third relationship may suggest that the wounded man is curing himself by making good amounts of bactericides, and when this is the case the physician should not interfere materially. These indications are more refined than are symptoms as ordinarily understood.

The necessities of the war have given great opportunity for the physician to test these methods. It is true that they do not fit all cases, but they have furnished in great quantity the most valuable information.

One difficulty in this or any other technique of the kind is the multiplicity of species of bacteria in the same wound. The opsonic index will give its readings only with reference to a single species and may not have to do at all with the germ that is causing the infection, while pyoculture has comparable deficiencies in its indications. But nevertheless it is true that these laboratory methods can in certain cases indicate the need of medical intervention where the usual diagnosis is at fault and can not clearly determine, and, on the other hand, suggest abstaining from operating where it may prove useless.

The question of the treatment of infections is a very difficult one, in which the evolution of opinions is proceeding very rapidly to-day. There have been in general two practices, asepsis and antisepsis. The former contents itself with preventing the introduction of germs into the wound and leaves to the body of the patient the task of defending itself by natural means against infection. It is used to-day in all surgical operations, but it is altogether insufficient under conditions of war with its great wounds and fatigued soldiers. Here antisepsis is imperative.

At the beginning of the war tincture of iodine was considered the ideal preservative against infection. It was even abused so that injuries like burning followed its use in a mixture too concentrated. To-day it is still employed, but only to wash the skin and the edges of the wound. It is not employed at all to act against the formation of pus. Since Lister's time the number of antiseptics has increased considerably and includes carbolic acid, corrosive sublimate, iodine, formaldehyde, permanganate, hypochlorites, ether, and their mixtures and derivatives.

It should be remembered that the action of these disinfectants is destructive and they not only attack the microbes, but the living cells. At the same time that they kill the germs they attack the leucocytes, which are the principal defense of the body, a double and contradictory action. The ideal would be an antiseptic that would destroy only microbes, but unfortunately this has not yet been discovered. So the use of disinfectants has been according to the personal knowledge and experience of the surgeon.

Various attempts have been made in these last months to secure a perfect antiseptic, but the results are all so new that it is yet too early to form an opinion about them. July 26th Henry D. Dakin presented to the Academy of Sciences (Paris) a note recommending certain chlorine derivatives. He expressed the choice of a disinfectant to be that one which shall have germicidal effect, penetration and absorbability, weak action as a poison and as a local irritant. Because they do not measure to these standards Mr. Dakin rejects most of the hypochlorites, but he suggests this formula: In 10 liters of water dissolve 140 grammes of carbonate of soda and 200 grammes of chloride of lime. Shake and filter. The liquid obtained should be rigorously neutralized with boric acid in the presence of phenol-phthalein. This solution has been employed by Dr. Carrel with excellent results.

At the front the use of this disinfectant has seemed to be very beneficial, but the wounded are so quickly sent to the interior hospitals that one man's observation can not follow them to judge of the later effects.

Mr. Dakin has likewise experimented with other substances, one of which is reported to be fatal to *B. perfringens* at a dilution of one ten-millionth, but does not affect the tissues even with the strength of four one-hundredths.

Very recently, in the *Presse Médicale* of September 27th, Delbet and Karajanopoulo have made known the first results of their researches in the same matter of disinfecting wounds. They also call attention to the danger of using antiseptics that attack the flesh or tissues. From their experiments with various substances the authors note that bactericidal power is very uneven, and they have made a descending scale of disinfecants in point of strength in this order: ether, permanganate, formula of Labarraque, Dakin's liquor, formaldehyde, cyanide of mercury and dioxygen. No one of these antiseptics favors the devouring action of the phagocytes so well as a salt solution (8 to 1,000 parts), which does not injure the cells, but even favors their preservation. These investigators have concluded that it is much better to employ liquids of this nature which stimulate the phagocytes rather than the older ones of destructive antisepsis.

In the course of their researches Delbet and Karajanopoulo have discovered another interesting fact—that chloride of magnesium (12.1 to 1,000 parts) in a group of microbes and phagocytes provokes much greater activity among the latter than human serum. This idea has not yet been fully tested, but it indicates the possibility of a new treatment, which may even be developed before the end of the war.

And this is the status of war disinfection of wounds in France.

Metastability of Metals

By A. Vosmaer

In continuation of the article on the metastability of bismuth, antimony, potassium and copper, I shall now give a brief account of the publications of Prof. E. Cohen of the Van't Hoff Laboratory, Utrecht, in the *Transactions* of the Royal Academy of Science, Amsterdam, Holland, on the metastability of other metals.

The importance of the subject may well be judged from Professor Cohen's statement: "Physical constants of metals, as they are given to us for the present, have to be considered as chance values, which are a function of the past thermal history of the material experimented upon." (*Zeitschrift für Physikalische Chemie*, 1915). All of us who have to do with physical constants are fully aware nowadays that the greater majority of figures given in the usual tables are nothing but approximations, good enough for orientation, but no more than that, and certainly they are far away from being as accurate as is suggested by the number of decimals which are usually given. Accurate recent determinations of the electric conductivity of "pure copper" of recent date, range from 62 to 65.2, so we should be very cautious when trusting to figures for properties.

To Cohen we are obliged for the explanation *why* it is that there is such a diversity in the figures for physical constants; indeed, there is very little constancy in them. Cohen has conclusively shown that if a sample of a metal is chemically pure, this does not necessarily mean that it is also physically pure; that is, a 100 per cent metal M may be composed of b per cent alpha M, c per cent beta M, d per cent gamma M, etc.

The allotropic modifications of a metal exercise a very marked influence on its properties, and for this reason a figure for some property is a chance figure, its value depending on the ratio of alpha, beta, gamma, etc., modifications in the sample. Add to this the fact that the state of molecular equilibrium is not the most frequent one in ordinary metals and that, on the contrary, all metals are as a rule in a metastable state, and it will be easily understood that the past history of a metal or alloy is of paramount importance because it determines the mutual ratio of allotropic modifications. It goes without saying that the *thermal* past history is of chief importance in this connection.

ALLOTROPHY OF CADMIUM.[1]

Matthiesen's researches on the electric conductivity of metals (1862) are familiar to every student. In fact, notwithstanding the early date of his experiments, his figures are quoted in a great many instances, and some still accept Matthiesen's standard copper = 100, although modern copper has a conductivity higher than 100, according to this scale, and although the modern system of units should be preferred to any arbitrary scale of obsolete character. Even Matthiesen in his day noticed for cadmium a marked molecular change at a certain temperature (80 deg. Cent.).

Cadmium, like most metals, shows the usual inertia for change, and the retardation is so great that special precautions have to be taken to notice the change; this is probably the cause why the allotropic modifications have escaped the attention of former scientists. The change, alpha to beta cadmium, occurs at 64.9 deg. Cent. The beta cadmium has a larger specific volume than the alpha modification; this explains Matthiesen's observation that at 80 deg. Cent. his sample of cadmium was so brittle as to fall to pieces.

From measurements with the pyknometer and the dilatometer, Cohen and his pupils concluded that cadmium has a transition temperature at 64.9 deg. Cent. and that this metal in general is a metastable system in consequence of the very strongly marked retardation which accompanies the reversible change of the allotropic modifications, both below and above their transition points.

Former experiments on copper and zinc pointed to the desirability of investigating whether or not cadmium did or did not exist in more than two allotropic modifications, and further research proved that like copper and zinc and other metals, cadmium may exist as alpha, beta and gamma cadmium, the proportions of which depend on the past history of the sample, and this being so, the transition point 64.9 is only an apparent one. It seems probable that above 100 deg. Cent. the gamma cadmium is the stable form and below 50 deg. Cent. the alpha cadmium, so that in between 100 deg. and 50 deg., cadmium is chiefly beta cadmium.

The exact behavior of cadmium is of paramount importance for the construction of standard cells, as each cadmium modification has an electrolytic potential of its own.

Ordinary cadmium has to be stabilized to the alpha form before use in a cell, if not, the "standard" voltage is bound to vary, to decrease, until all the metal has been changed to alpha cadmium.

It may be well to mention here that the metastable transition point of the reaction alpha cadmium $\rightleftarrows$ gamma cadmium is 94.8 deg. Cent., and that if one gramatom of alpha cadmium is transformed into gamma cadmium, the change is accompanied (at 18 deg. Cent.) by an absorption of 739 grammes calories. Electrolytically deposited cadmium is not the stable alpha, but the unstable gamma cadmium. This fact is quite in accordance with what should be expected and is of practical importance, since the method of making cadmium cells is to deposit the metal electrolytically. This is another instance of the common phenomenon that it is not the stable modification of a metal that is first formed, but the stable form has to be reached *via* unstable forms.

The conclusions arrived at are: First, that the metal cadmium, as familiar to us, is a metastable system containing more than two allotropic modifications, and, second, many of the mysterious phenomena belonging to cadmium cells can be explained when taking into consideration the above-mentioned fact.

ALLOTROPHY OF LEAD.[2]

Rather large discrepancies in the physical constants given for lead indicate that here again we have to do with a metal in more than one modification.

The density of purest lead (Kahlbaum 0.001 per cent Cu, 0.0006 Fe) taken as 11.324, increases to 11.341 after treatment at 15 deg. Cent.; it decreases again to 11.313 after treatment at 50 deg. Cent., and it increases again to 11.328 after treatment at 25 deg. Cent.

The experiments have not yet been concluded, but from what could be observed it is evident that lead, as it has been known up to the present, forms a metastable system containing simultaneously several allotropic modifications of this metal.

The well-known form of lead as a lead-tree is one of the metastable modifications.

ALLOTROPHY OF ZINC.[3]

Scientists seem to have recognized as early as a century ago that zinc is not always the same substance. Practical men have known as long as they have used zinc that one of its peculiarities is that in summer time it expands, but after return to average temperature it does not return to its original dimensions.

In a cold winter, zinc contracts, but never again resumes exactly the original length, and everyone familiar with zinc roofing knows that zinc should never be cut lengthwise, but always crosswise, though the greater length lengthwise would encourage one to do otherwise if he has to make long strips for tubing or other building purposes.

Practical men know that new zinc possesses that property of not resuming again its original length in a much greater degree than old zinc. Real trouble may result from neglecting the fact that zinc, and more especially sheet zinc, is a metal not to be trusted as regards its length. In case we have circular disks, as is often the case with instruments, warping is the effect of said unequal behavior lengthwise and crosswise the direction of rolling.

The researches of Cohen have not elucidated the strange phenomena. They are strange unless they also can be attributed to metastability at ordinary temperatures.

Practical men also know that zinc cannot be rolled unless heated to a temperature of about 120 deg. Cent., and they also know that zinc can very easily be pulverized when heated to about 200 deg. Cent. Cohen did find that prolonged heating to 25 deg. Cent. had a very marked influence on the density of the zinc. A considerable contraction occurred. Further data are promised by Cohen.

For another transition point, temperatures of 350 degrees, 321 degrees, 330 degrees, 300 degrees are given by different authors, also 170 degrees, so that for the present it is best to wait until Cohen and his collaborators will have finished their determinations.

ALLOTROPHY OF SODIUM.

The change from alpha sodium to beta sodium does not occur, but beta sodium changes to alpha at a temperature of about 95 deg. Cent. The transformation of sodium evidently is a case of monotrophy that means that the change of one modification into the other is not reversible, it goes one way only. For the present this fact is hardly of any technical importance.

The lesson to be learned from these results is that all numerical data bearing on physical constants have to be revised or checked. No figures should be trusted, and experiments should be carried out on pure metals in their stabilized form. Physical "impurities" in the form of allotropic modifications influence the properties quite as strongly as chemical impurities.—*Metallurgical and Chemical Engineering.*

[1] Communications, Oct., 1913; May, 1914; Oct., 1914; Jan., 1915.

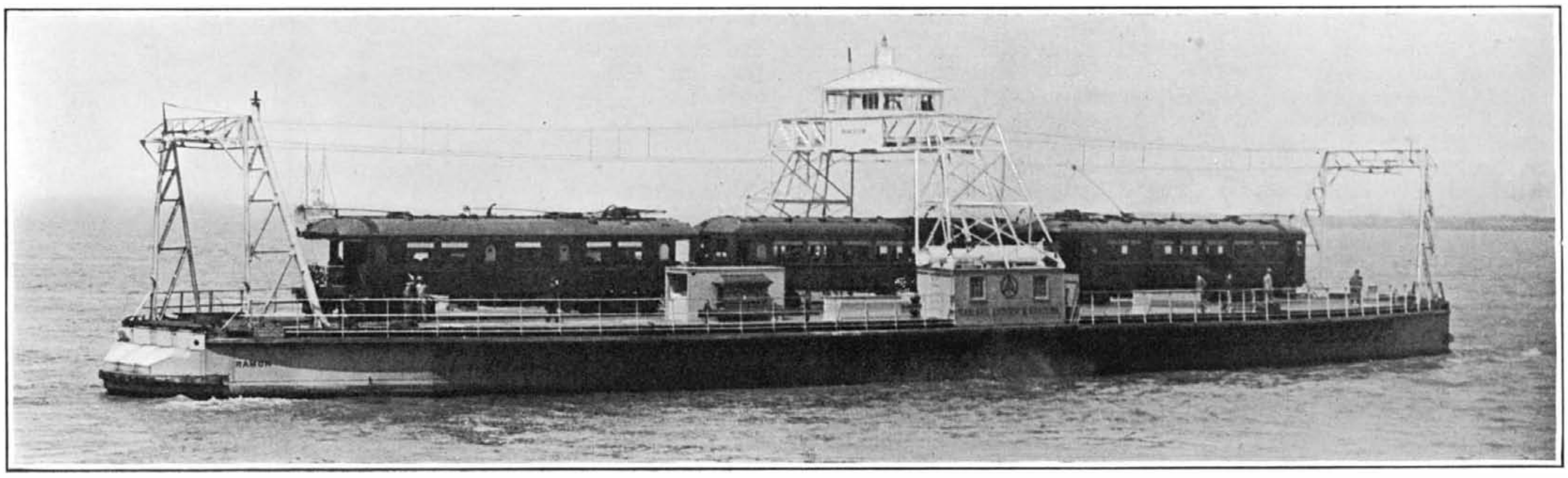
[2] Communications of Nov., 1914; Jan., 1915.

[3] Communicated Nov., 1913; May, 1914; Oct., 1914.

An Old Boiler Explosion Theory Confirmed

Over 50 years ago a genius named D. K. Clark originated a theory in regard to the explosion of steam boilers, which was published by Zerah Colburne, an authority on engineering subjects at that time. Conthary to the general impression held for many years since, that such an explosion is instantaneous, Clark held that it may be a succession of several operations, which may be stated as follows: (1) The initial rupture, either at or above working pressure, may take place in or near the steam space with extremely rapid discharge of steam and water. (2) A consequent reduction of pressure in the boilers so rapid that it may become considerable before the inertia of the mass of water will permit its movement. (3) The sudden formation of steam in great quantity within the water and the precipitation of heavy masses of water toward the opening, impinging upon adjacent parts and breaking it open, causing large openings or extended rents, and often shattering the whole structure into numerous pieces. (4) The completion of the vaporization of the liberated water and the expansion of the steam formed projecting the detached parts to distances depending on the extent and velocity of this action. This series of phenomena may accompany any explosion, whatever the initial cause. A local defect well below the water line would act as a safety valve, discharging the contents of the boiler without explosion.

Observations made at some recent explosions tend to confirm this old theory, which contains matter that merits full study and investigation.



The car ferryboat "Ramon," which is powered by the largest gasoline engines ever built.

The Largest Gasoline Ferryboat

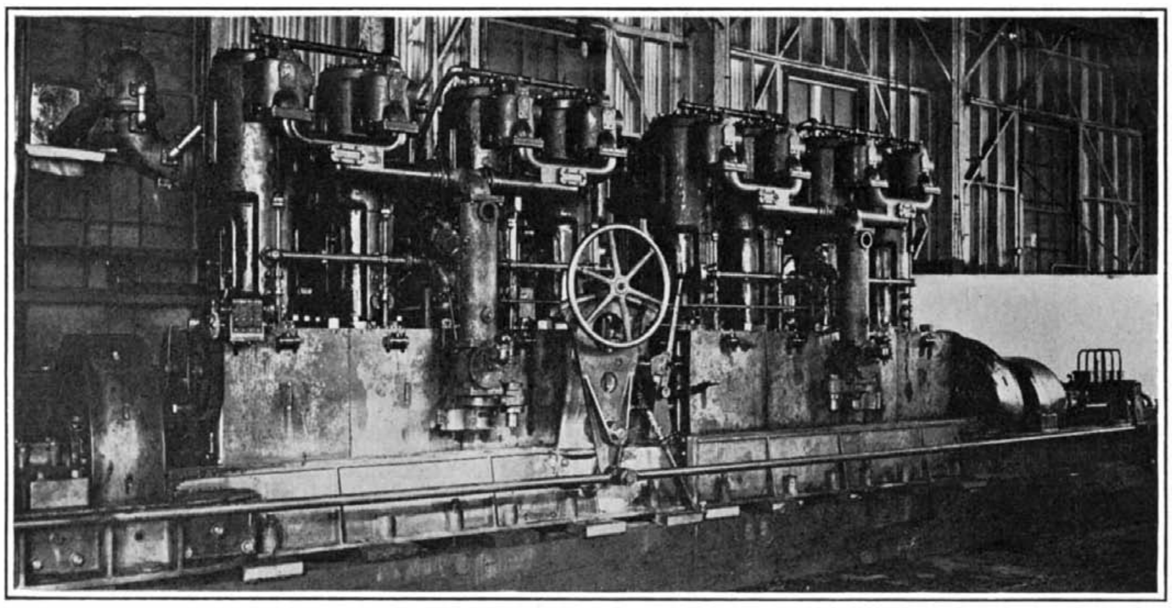
A Successful Application of Gasoline Engines in Exacting Service

ONE of the recent applications of the gasoline engine for marine purposes is in a large ferryboat that is used for transferring railway trains across a part of Suisan Bay near San Francisco, in which work it has been most successful and satisfactory. One of the illustrations show the boat as it appears in service, and the method of arranging the trolley wires to allow of the trains running onto and off the boat is clearly shown, for the road in connection with which the "Ramon" operates is a modern high-speed electric road. The other picture shows the powerful gas engines that propel the boat as they appeared assembled in the builder's shops.

The "Ramon" is of steel construction throughout and is owned by the Oakland, Antioch and Eastern Railway. The vessel measures 236 feet in length, 58 feet in width, and has a maximum draft of 12 feet. There are three tracks on the main deck, the rails being flush with the wooden planking laid over the steel deck. The "Ramon" is constructed of steel throughout, and great structural strength and stiffness is provided by two longitudinal truss bulkheads extending the entire length of the vessel, and four transverse bulkheads across the full width. These also divide the hull into eleven watertight compartments, adding greatly to its safety.

The arrangement for the propulsion of the "Ramon" is rather unusual for a motor-driven craft, although the same scheme has been used for steam vessels of similar character. The propelling engine is set amidships and is a 600 horse-power unit. This engine measures 43 feet over all, and weighs approximately 120,000 pounds. It is coupled to a propeller at each end of the vessel through friction clutches, and as the two propellers are of opposite pitch the necessity for reverse gears and reversing the engine itself is eliminated. The wheel operating the two clutches is seen in the middle of the picture illustrating the engines.

It is claimed that the "Ramon" is the world's largest gas engine ferryboat, and it has been in successful operation for about a year. The Oakland, Antioch and Eastern Railway maintains a quick service between San Francisco and Sacramento, and during the entire time the "Ramon" has been in commission there has never been a single delay in the passenger train service on account of the ferry.



600-horse-power gasoline engines for the car-ferry "Ramon."

Electricity in the Field of War*

Every Convenience of the City to be Found at the Front

THE civilian is apt to think that the employment of electricity in war is confined to telegraphy, with or without wires, and telephony, and to lament, as he turns on his electric light, that the soldiers in the field enjoy no such conveniences. This is an error. It is true that the most advaced trenches are not usually lighted by incandescent lamps—though some captured French trenches were found thus furnished—but behind the trenches the existing electrical central stations are operated, if possible, and the distributing wires have been extended to furnish current for various uses. Every company of German reservists includes a number of electricians, and after the war many a farmer will find his house and barns furnished *gratis* with the electrical installation that he had formerly deemed, and may still deem, quite unnecessary.

The restoration of abandoned and damaged electrical stations was often difficult, involving extensive repairs of the old machines and even the construction of new ones. Entire new stations have also been created, some of a very simple type for local use, others more elaborate for feeding circuits formerly supplied by stations still within the lines of the enemy, who silently refuse to supply current to conquered territory. Two large villages were lighted by a dynamo found in a ruined factory, driven by a steam locomobile, formerly used to drive a threshing machine. In another place a steam road roller was pressed into service for supplying the desired current.

Mobility is of the utmost importance in war. All military equipment must be easily transportable. Even traveling electric generating stations are used in the present war. These stations are simply the gasolene-electric cars which the Prussian-Hessian railway has been using experimentally for several years. The car is propelled by an electric motor, connected with a dynamo which is driven by a gasoline-motor. These cars are very useful in the construction of railways in the enemy's country, almost silently conveying material and tools, and furnishing light for work at night and in tunnels. The cars also furnish current for searchlights, but separate dynamos are provided for the powerful searchlights of the pioneer companies, which emit beams of several hundred thousand candle power that bring almost certain death to the enemy on whom they fall. Similar searchlights were used in the airship raids on the English coast.

The pioneers also employ electricity for exploding mines. A small induction coil suffices for the work. This method of destruction is more reliable than the fantastic scheme of electrifying all wire entanglements.

The employment of electricity for communication is too vast a topic to be discussed in detail, but it may be mentioned that the telephone is generally used between headquarters and the front, and the telegraph between headquarters and the rear, and that both are usually operated with small dry batteries.

Wireless telegraphy was first used in war in the Herro rebellion, in which it did good service, despite the crudeness of the apparatus and its unsuitability to a tropical climate. In the present war the great fixed wireless stations alone have maintained communication with lands beyond the sea, as all the German cables are cut. In the field small traveling stations have been employed to an unexpected extent from the beginning of the war. The rapid advance of the German armies made it impossible to establish ordinary telegraphic connections with sufficient promptness, and the traveling wireless station proved very useful. Scouting cavalry troops are provided with such stations, and others varying in type and power are distributed among commanding officers. In general, the wireless stations employed near the front are drawn by horses, and the others are mounted on motor cars.

A few other uses of electricity in war, apparently small but very important, deserve mention. The motor car has proved indispensable for conveying supplies, transporting wounded and many other purposes, but what would the motor car be without its reliable magneto or battery ignition? The airship and the aeroplane also depend, for their efficiency, on these devices. The electric pocket lamp has guided many a soldier through dark places and enabled many an officer to consult his map, when the issue of life or death depended on its inspection. The soldiers cherish and covet these little lamps above all else.

Electricity is also used extensively in the army for medical and sanitary purposes, especially for Röentgen ray photography, and for sterilizing water by means of traveling ozonizing apparatus.

* Abstract of an article by Lieut. M., in *Die Umschau.*

An Ingenious Method of Heating Rooms.—An ingenious method of heating small rooms, the walls of which are partially or wholly composed of tiles, has been suggested. By means of the spraying process a thin metal coating, preferably arranged in an ornamental pattern, is spread in the tile wall, and this is connected to some source of electricity, the metal pattern on the non-conducting tiles forming a heating element.

Washing Locomotive Smoke*

How a Serious Local Nuisance Was Overcome

The New York Central engine house in Chicago is located at Englewood station, near Indiana Avenue and Sixty-third Street. It is adjacent to the White City, a popular amusement park, and surrounded by a very desirable residential district. The citizens are very insistent on the abatement of smoke, and object to the excessive use of the blower which is sometimes necessary for this purpose. While the New York Central locomotives west of Buffalo are equipped with the steam jet smoke consumer, which induces a flow of air above the fire and under the brick arch, and large blower capacity consisting of two 1¼-inch blowers, one on the right and one on the left side, it is found that these appliances are of little assistance in the elimination of smoke when building a new fire in a cold locomotive. This was the great problem which confronted the mechanical officers of the New York Central in 1910, when it was found necessary to build a new engine house and terminal facilities at the Englewood station.

O. M. Foster, master mechanic in this territory at that time, after a careful study of smoke-washing devices which had been tried at other places with partial success, conceived the idea of forcing the smoke through a large body of water, by means of a fan separating the unconsumed carbon from the gas, permitting the latter to escape through a high stack and holding the carbon and other solids in suspension in the water. D. R. MacBain, superintendent of motive power, who had made a life-long study of smoke-abatement devices, approved of the plan. A small plant was built at Elkhart, Ind., capable of taking care of one locomotive, which gave results beyond expectation. To more thoroughly test the device, an experimental plant was built at Collinwood, Ohio, to take care of several locomotives. With the data collected from this experimental plant, the present smoke washer at Englewood was designed and constructed. The only drawback was in securing material that would withstand the powerful action of the various acids resulting from the combination of the gases, the solids and water.

The Englewood engine house has thirty stalls, in which from eighty to one hundred locomotives are handled every 24 hours. It is built without a single smoke jack leading direct to the atmosphere. In washing the smoke, a large concrete tank, 22 feet by 32 feet, is used. This is subdivided by separating walls into three basins, each of which is lined on the interior with dressed lumber set in about 1½ inches from the concrete. The space between the concrete and the lining is filled with tar. Wooden pins, instead of nails, are used for fastening the lining, in order to resist the action of the acids. The drawings show the plan and elevation of the tank, the stack, the three hoods, the three ducts connecting the fan with the concrete basin, the fan and motor and the elbow connecting the fan with the large smoke duct in the engine house to which the smoke jacks connect.

A large smoke duct, 60 inches in diameter at the center and tapering to 36 inches at the ends, extends around the engine house just under the roof and directly above the smoke stacks of the locomotives when the latter are headed in and standing in normal position. This smoke duct was built of transite material, and is connected with drop pipes leading down to each pit. In each of these drop pipes is a damper which is closed when the jack is not in use. Leading from each drop pipe is a telescopic jack made of cast iron and supported from the roof. These telescopic jacks have vertical, lateral and longitudinal movement to accommodate different positions of the locomotive stack. They are raised and lowered by a walking beam, counterbalanced with a weight and operated from the wall of the engine house. The damper is opened and closed from this same point.

Near the center of the house a large elbow connects into the top of the 60-inch transite duct and leads down to a 78-inch steel plate, double-inlet fan, capable of handling 68,000 cubic feet of gases at 500 degrees per minute, at a total static pressure of 14 inches at the fan outlet, and at a speed of 950 r.p.m. The fan is belt-driven by a 300 horse-power constant speed, 300 to 400 r.p.m. motor. A smoke duct leads from the fan to each of the three concrete basins, the outlet to each duct coming directly under the hoods referred to above. There are three hoods in each tank. The top of the interior hood is open, while the top of the second hood is closed similar to a bell; the top of the third or outer hood is open and connects with the stack, which is approximately 60 feet high. The three smoke ducts leading from the fan, the hoods and the stack are made of wood pinned together with pegs instead of nails. The lower portions of the hoods are submerged in the water in the tank to insure thorough contact of the smoke with the water.

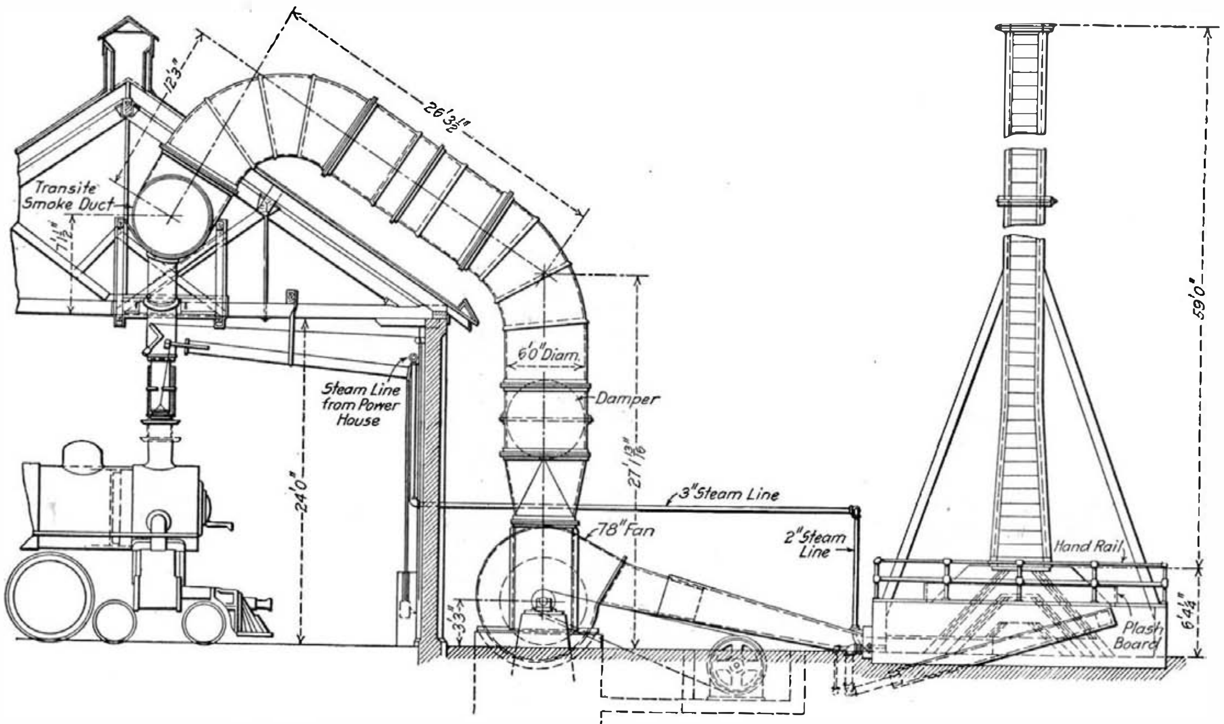
An 8-inch hole is provided in each of the separating walls to insure a uniform level of water in the three basins. A special overflow pipe is provided to maintain 14 inches of water in the tanks and to prevent the carbon from escaping into the sewer. A 1¼-inch high-pressure steam jet, with proper elbow and nozzle pointing toward the outlet, is located in each of the three ducts and close to the concrete tank. The purpose of these steam jets is to accelerate and thoroughly mix the gases with the water and prevent them passing through the water in large bubbles. The gases are forced from the fan through the three smoke ducts into the water, passing out into the first hood. The water being thoroughly agitated at this point by the steam jets referred to, the gases are engulfed by the spray and wave action of the water and pass out through the top of the first hood into the second hood or bell, which, it will be remembered, has a closed top. They are forced down below the lower edge of this hood and pass to the third hood, and out of the water into the stack.

The carbons and solids are separated from the gases as they are forced through the water and rise to the top of the water in the tank in the form of a black, foamy scum. The gases pass out through the stack as a white vapor, practically odorless. In handling eighty locomotives in 24 hours, from eight to ten barrels of carbon are obtained from the smoke washer. This has the appearance of lampblack, and is thoroughly steam-dried after it is taken from the smoke washer. An analysis of this material is as follows:

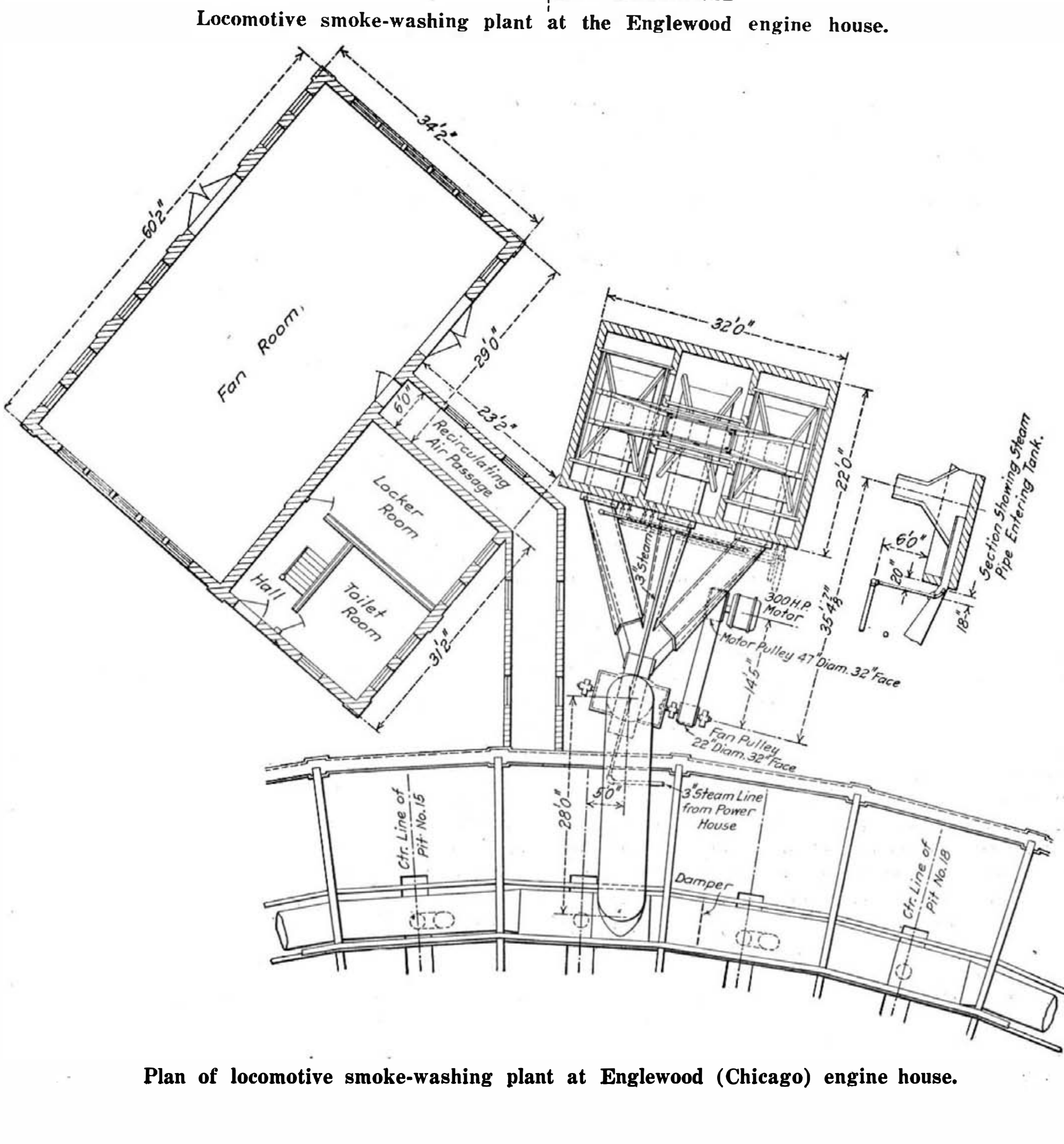
Moisture	3.9 per cent
Carbon	82.6 per cent
Sulphur	2.6 per cent
Iron oxide	8.7 per cent
Silica	1.8 per cent
Calcium oxide	trace

The sulphur and sulphuric acids are retained in the water. The city smoke department of Chicago and the nearby residents are well pleased with the results obtained and on numerous occasions have complimented the plant very highly.

The estimated cost of making such an installation is from $15,000 to $18,000, where the property conditions are favorable. Owing to the property conditions and to



Locomotive smoke-washing plant at the Englewood engine house.



Plan of locomotive smoke-washing plant at Englewood (Chicago) engine house.

* Abstract of a paper presented at the tenth annual convention of the International Association for the Prevention of Smoke, by M. D. Franey, Master Mechanic of the New York Central Lines, at Elkhart, Ind., as published in the *Railway Age Gazette*.

the fact that the Englewood plant is an experimental one, the actual cost was somewhat greater. We made an investigation some time ago as to the cost of operation:

COST OF OPERATION PER DAY OF 24 HOURS.

Water, 18,255 gallons, at 7 cents per thousand	$ 1.28
Coal, 10.86 tons, at $1.75 per ton	19.00
Electricity, 3,360 kilowatt hours, at $0.0129	43.34
Total	$63.62

SAVING EFFECTED BY THE USE OF WASHER PER DAY OF 24 HOURS.

Fires maintained	$40.80
New fires built	7.11
Reduced electrical cost due to sliding scale rate	8.52
Total	$56.43

This makes the net cost of operating the washer $7.19 per day of 24 hours ($63.62 less $56.43). It is expected that we will be able to find a profitable use for the lamp-black reclaimed by the smoke washer. This would, of course, result in still further decreasing the net cost of operation and might possibly show a profit.

We have found that where the fires are properly started the draft from the fan is sufficient to draw off the gases from the locomotive without the use of the blower. This means a decided reduction in the amount of water used, due to not using the steam blower, and also means a decided saving in coal consumption, due to the reduced draft. While we have quoted the results of some tests, it is difficult to obtain a set figure as to the amount of coal and water consumed by an engine at a terminal due to varying conditions, such as smoke restrictions, temperature of the weather, and the human element or fire-up men. However, the tests showed to our entire satisfaction that the coal and water consumption is materially reduced on engines stored under the smoke jack and influenced by the draft of the smoke washer fan. The temperature of the firebox is more even and the fire-up man is able to handle a larger number of locomotives.

This smoke washer is operated under patents controlled by the American Smoke Washing Company, incorporated in Illinois, of which S. K. Dickerson, 5120 Greenwood Avenue, Chicago, Ill., is secretary.

The Control and Protection of Electric Systems*

Immense Increase in Production of Electric Power and Difficulties That Have Been Overcome

By Charles Proteus Steinmetz

When the first commercial electric circuit issued from a station the problem of control and of protection arose. It was a simple problem at first: an ammeter and voltmeter to measure current and voltage; a knife-blade switch to send the current into the desired path, or withdraw it; the fuse to open the circuit in emergencies; and, if the wires became crossed and fuse and switch failed, generator and engines stopped and not much harm was done.

With the extension of the circuits into the suburbs some lightning troubles were felt and led to the introduction of lightning arresters—in the early days based mainly on hope and trust in providence rather, as very little was known of lightning phenomena.

Since these days, less than a generation ago, enormous changes have taken place, and the electric systems have increased in size, in voltage and in extension.

Where 100 horse-power machines were large once, now steam turbine alternators of 40,000 horse-power and more are in commercial operation. The steam engine has made room for the steam turbine, and the steam turbine does not stop when the wires are crossed and a short circuit occurs, and the momentum of the turbine disks, revolving at velocities of 300 to 400 miles per hour, can supply ample energy for the destruction of any part of the system.

Feeders of 10,000 horse-power or more, generators of 40,000 horse-power have to be controlled by switching: an attempt to open such a circuit by the knife-blade switch of old would lead to the destruction of the switch—and probably its operator.

Instead of small machines operating separately on independent circuits, huge generators now feed in parallel into the system of busbars, on which is concentrated all the power of the station or the group of stations which are tied together. Numerous stations and systems of interconnected stations of 100,000 to a quarter million horse-power and over are in operation, and the half million horse-power mark has been reached.

Anywhere on the busbars of the station or in the feeders near the station there is available, destructively in case of an accident, as a short circuit, not only the entire power of the station, of perhaps half a million horse-power, but the far greater power which the station generators can give momentarily.

Short-circuit currents of forty to fifty times normal full load current may momentarily flow from some turbo-alternators, representing ten and more times full load power.

Such a station, or group of closely interconnected stations, of half a million horse-power full load capacity, may momentarily send into a short circuit at the busbars over 5,000,000 horse-power. This is the power of Niagara: for Niagara is estimated variously at from 5,000,000 to 15,000,000 horse-power.

It is obvious that no switch or circuit breaker can be built to safely open such power, to suddenly stop Niagara, especially when considering that many hundreds of feeders issue from the busbars, that in any one of these feeders a short circuit in the cable may let loose the power of the entire system, and every feeder thus requires such a circuit breaker.

With half a million horse-power station capacity, a momentary overload capacity ten times as high, assuming that we could build a circuit breaker to open this short circuit power as quickly as in three to four cycles, or one eighth second: this would require to dissipate in the circuit breaker the energy of over 200,000,000 foot-pounds—the destructive energy of 1000 tons dropping from a height of 100 feet. This is about the energy of a projectile of 2000 pounds weight leaving the cannon at the velocity of 2500 feet per second. It is the destructive energy of two heavy railway trains, of 400 tons each, going at 60 miles per hour, and meeting in head-on collision. It is the energy of the explosion of 30 pounds of dynamite.

Equally great has been the increase of voltage: where once 2000 volts were high-voltage distribution, in circuits of a few miles length, now circuits of hundreds of miles length are in operation at voltages of 100,000 to 150,000. Such voltages jump toward any object for over a foot distance, and will maintain arcs of practically unlimited distance; that is, with 100,000 volts and practically unlimited power back of it, an arc can extend for hundreds of feet. Thus no simple switch will open such voltages under power.

Transmission systems at high voltages have been interconnected with each other into networks, which spread and extend, and already to-day often represent thousands of miles of interconnected high-voltage lines, covering tens of thousands of square miles, and picking up every lightning, every atmospheric disturbance within this entire area.

Thus the lightning protection also has become a far larger problem than in the small circuits of old.

But far greater than the energy of any lightning stroke is the energy stored as magnetic field surrounding the conductors, as dielectric field radiating from the conductors of these big transmission systems, and if this internal energy of the system is set surging, its effects are far more destructive than those of lightning, and the effects may not be merely momentary, as those of lightning, but continual, as machine energy continually replaces the stored internal energy which causes the destructive surge.

And, in addition hereto, far greater reliability and continuity of service is to-day demanded from the electric systems than was in the early days, and that at a lower cost of electric energy; and it must be remembered that, with the increasing cost of living, electricity is one of the few commodities which has steadily decreased in price.

The foremost problem of control of electric systems thus is that of controlling enormous powers; the foremost problem of protection is that against self-destruction by its own power.

Current and voltage have grown beyond the values for which instruments can be built, and *current transformers* and *voltmeter transformers* are interposed between the circuit and the instruments measuring it. With the general introduction of parallel operation, *power-factor indicators* are required to insure the division of load without excessive waste currents; *frequency indicators* and *synchronizing devices* to safely connect machines into the system.

With hundreds of feeders radiating from the generating station, the office of the load dispatcher has become essential, and the necessity of keeping exact records of all operations and of all accidents and incidents is of the greatest importance. Automatic recording devices thus have been developed, as the *multi-recorder*, to record, within fractional seconds, all important events, as opening and closing of switches, starting and stopping of generators, surges, lightning disturbances, etc. Such automatic devices afford a valuable check on the operating staff, but more important still is their record in emergencies, where a number of things happen almost at once, where the attention of the operators is detracted from accurate observation by the necessity of action, and the record thus could be made only afterwards from memory, which is not very accurate in such a period of excitement. It is just in such abnormal conditions where the most complete and accurate record is of greatest importance, to enable the engineers to determine with certainty what happened and why it happened, so as to take steps to guard against its recurrence.

Oil circuit breakers have been developed, which can safely and without disturbance close and open the feeder circuits of over 10,000 horse-power, the generator circuits of 40,000 horse-power and more, with an ample margin of overload capacity. In these the circuit is opened under oil with such mechanical arrangement of contacts and oil vessel that in the moment of circuit opening the current is extinguished at the end of a half wave by the rapid expansion and chilling of the oil vapor which is produced by the opening arc, and which in the first moment is under high compression, due to the momentum of the oil, which has to be set in motion.

The most serious danger, in the growth of electric systems, was, however, the possibility of self-destruction by the power let loose under the short circuit, and there were anxious years for the operators and managers of these large electric systems before the industry devised the means of safely controling unlimited power. More than once, when a serious short circuit occurred and a disaster was averted only by luck, the system was cut into two or three sections and these operated independently, to limit the power. But when months passed without further accidents, invariably, due to the requirements of economy and reliability of operation, the sections came together again and parallel operation of the entire system was restored.

This, the most serious problem of the high-power electric system, was solved by the development of the *power limiting reactances*.

In the generator leads, between generators and busbars, are inserted reactances, capable of standing enormous overloads, of a size sufficiently small not to interfere with the normal flow of power at full load or any overload which the generator may be called upon, but large enough to materially limit the generator current and power at short circuit. Usually the *generator reactances* limit the momentary short-circuit current to about ten to twelve times full-load current; that is, the momentary short-circuit power to about two and a half times full-load power. This solved the problem for medium-sized stations. Thus in a 60,000 horse-power station, instead of a possible short-circuit power of over half a million horse-power, the power is limited to 150,000 horse-power.

However, even with generator reactances, with increasing size of station, the power which may be let loose under short circuit becomes large beyond control; with a 400,000 horse-power station, with generator power limiting reactances, a million horse-power may still be concentrated at a short circuit.

Busbar reactances then were introduced; that is, the busbars divided into sections by reactances sufficiently small not to interfere with the interchange of power along the busbars, and thereby retaining the advantage of parallel operation, but large enough to limit the flow of power, which, in case of a short circuit on one busbar section, can flow into it from the adjoining sections.

With such reactances in the busbars and in the tie feeders between the stations, the system is divided into sections of about 60,000 horse-power each. A short circuit then can seriously involve one busbar section only, and the destructive power of a short circuit is limited to that of one section, plus the limited power which can flow from the two adjoinging sections, a total of 150,000 to 200,000 horse-power, and this is within the emergency limit of the modern oil circuit breaker of moderate size. It still represents a terrific energy, nearly 10,000,000 foot-pounds, and is a severe strain on the circuit breaker.

These busbar reactances permit an unlimited extension of the system, and the short circuit on a section of a half million horse-power system is no more severe than a short circuit on a 100,000 horse-power system, and there is now no limitation to the future increase to electric systems of many millions of horse-power capacity, operating in parallel on one set of busbars.

With hundreds of feeders radiating from the busbars,

* A paper presented before the Electrical section of the Franklin Institute and published in the *Journal* of the Institute.

the probability of a short circuit in feeders is far greater than in the busbars, and a material advantage, therefore, is given by *feeder reactances*; that is, reactance interposed between the feeder or a group of feeders and the busbars, so that a short circuit in the feeder is still more limited than a short circuit in the busbars.

By the development of generator reactances, busbar reactances, and feeder reactances, the problem of the power control of large systems for protection against self-destruction by short circuit has been solved and unlimited extension of systems without any increase of danger has been made possible, and experience has shown that after the introduction of such power-limiting reactances dead short circuits have occurred at the busbars of very large systems without even interfering with the operation of most of the synchronous apparatus on the system.

Not all three classes of reactances are always necessary; in systems of moderate size busbar reactances may not yet be needed. In low-head water-power plants, with slow-speed multipolar alternators of inherently limited short-circuit current, generator reactances may be unnecessary and only busbar reactances required. Such, for instance, is the case at the Keokuk plant on the Mississippi River. Again, with a perfect system of generator and busbar reactances, feeder reactances may be dispensed with—though they are even then an advantage.

In high-voltage transmission networks, even of very high power, power-limiting reactances sometimes may not be required or are less essential. With a considerable number of medium-sized water-power plants feeding into a transmission system, the power of each individual generating station may not be sufficient to give destructive values under short circuit, and the impedance of the lines between the generating stations may be sufficient to limit the power which can feed into the short circuit at one station. In transmission networks, therefore, power-limiting reactances are necessary only in very large generating stations, such as the Keokuk station, or where several fairly large stations are close together, and also, as generator reactances, in turbo-alternators connected into the system as steam reserve.

To cut off a disabled line or feeder with the voltages and powers of our modern systems is beyond the capacity of the fuse or simple blade switch, and automatic oil circuit breakers are generally used. However, the problem has become more difficult by the increasing demand for reliability and continuity of service.

The two main sources of troubles in lines and cables are *grounds* and *short circuits* between phases. In transmission lines a ground on one phase is the most frequent trouble, and short circuits are rare except in lines in which the design was faulty, or reliability had been sacrificed to cheapness, and the spacing between conductors chosen too small, so that they swing together during wind storms, etc. A short circuit is far more serious than a ground, as in the former the current is limited only by the generator capacity, while with a ground the current has no return—except if the neutral is grounded, and then over the resistance of the neutral—and the current, and with it the shock on the system, is therefore very much less, especially if safeguards against the occurrence of high frequency by *arcing grounds* are installed. In a well-designed transmission line a short circuit usually occurs only as the result of two simultaneous grounds. A ground on one conductor, however, raises the voltage against ground of the other two phases, from the Y voltage to the delta voltage of the system, and thereby increases the strain on the insulation of the other two phases. It thus either introduces the danger of a second ground, causing a short circuit, or requires a higher grade of insulation.

This has led to two methods of operation of transmission systems. In one the neutral of the transformers is grounded, frequently through a resistance where the resistance of the ground is not high enough to limit the current. Then a ground on one phase is a partial short circuit to the neutral, and causes a large current to flow and thereby opens the automatic breakers and cuts off the circuit before the ground has developed to a short circuit. However, this method, the "*grounded Y system*," means a shutdown at every ground, every flashover of an insulator by lightning, etc. In the other the neutral of the system is not grounded, the insulation of the circuit being made good enough to safely stand the increased strain put on it by a ground on one phase, and by an *arcing ground suppressor*, etc., care is taken not to continue an arcing ground—leading to high frequency disturbances—but convert it into a metallic ground. In this case, the "*isolated delta*" *system*, service can be maintained on the circuit, even if one phase grounds, until arrangements are made to take care of the load, or the fault found and remedied, and the continuity of service is not interfered with. However, the cost of line construction is higher, due to the better insulation required. The relation between grounded Y and isolated delta thus is that of cheapness *versus* reliability and continuity of operation, and, as a rule, we find grounded Y systems where lowest cost of development is considered essential and occasional interruption of service not considered objectionable, while the isolated delta is generally preferred in systems in which reliability and continuity of service are considered as of first importance, such as in the extension across the country of the great Metropolitan Edison systems—systems which are proud of their record that the voltage has not been off their busbars for ten years or more.

Different are the conditions in underground cable systems. In a cable the three conductors are so close together that a ground on one conductor quickly reaches the other conductors and becomes a short circuit. A grounded cable, therefore, cannot be kept in service, but has to be cut out as promptly as possible. In these systems it therefore is customary to ground the neutral through a resistance sufficiently low, in case of a ground on one conductor of a cable, to allow sufficient current to flow to open the circuit breaker and cut off the cable, but sufficiently high not to give a severe shock on the system. Or, where grounding of the neutral is considered undesirable, an arrangement of relays is made to give the same effect. With underground cables such cutting off of a disabled feeder does not interfere with the continuity of service, as a number of feeder cables are always used in multiple for every important substation.

However, the problem of cutting off a disabled feeder by the operation of the circuit breaker, due to the large current taken by the grounded feeder, is not so simple. Assuming that three cables feed in multiple into a substation, and one of these feeders grounds: a large current then flows from the generating station into this cable to ground, and the circuit breaker at the generator end of this feeder opens. This, however, does not stop the current rush, but a large current still flows through the damaged cables into the ground, coming back from the substation, and flows to the substation from the generating station through the two parallel feeders, which are undamaged; that is, short-circuit current feeds back through these two cables over the substation, and these two cables also open their overload circuit breakers, cutting off and thereby shutting down the substation. If the substation is connected by tie feeders to adjoining substations, current feeds back into the faulty cable over these tie feeders from adjoining substations, and these tie feeders, and the cables feeding the adjoining substations from the generating station, open their circuit breakers by overload. and in this manner a ground in one cable may shut down a number of substations, possibly the entire system. *Time-limit devices* in the circuit breakers are insufficient to protect against such extended shutdowns resulting from a single fault in a cable. A permanent time-limit is not permissible in large systems, as with a dead short circuit the circuit breakers must open instantly before extensive damage is done by the large power of the short circuit. Therefore, so-called "*inverse time-limit*" circuit breakers are generally used; that is, circuit breakers in which the time limit of their operation decreases with increasing overload. Such circuit breakers would first cut off the cable carrying the greatest excess current—that is, the faulty cable—and then those of less excess current; but, as with the cutting off of the faulty cable—at both ends—the excess current stops, other cables should not be interfered with. However, the inverse time-limit circuit breaker necessarily must be practically instantaneous under short circuit, and therefore, while the time limit discriminates between 100 or 200 or 300 per cent overload, it cannot discriminate between short circuits of various severity; that is, not only the faulty cable, but its parallel undamaged cable, and the tie cables to other substations, etc., would open, and, while the extent of the shutdown would be somewhat limited, it is still far beyond the extent permitted by reliability of service.

Thus devices become necessary to select a disabled feeder and cut it out without cutting off its parallel feeders or the tie feeders to the substation served by the faulty feeder, regardless of what excess currents these may carry. This is a problem which has not yet been completely solved.

As the result, in general, in high-power systems of high standard of reliability the radial system of substation supply is used; that is, each substation is fed by a separate set of cables, and the substations are not interconnected into a network by a system of tie feeders. This radial system, however, is materially less economical in feeder copper than the interconnected network, since the radial system requires for each substation a feeder capacity equal to the maximum power demand of the individual substation, while in the network, by cross-feeding between the substations, the feeder capacity is reduced to that required by the average maximum demand of the substations.

To avoid a shutdown of the substation by a fault in one of its feeders, the different feeders of the same substation are not connected in parallel in the substation, but feed separate translating devices, as transformers and converters, and are paralleled in the substation only on the secondary side of transformer or converter. In case of a faulty feeder, the current feeding back into the fault over the other feeders of the same substation, therefore, has to pass through two sets of translating devices, and this limits it sufficiently to allow the time limit relay of the circuit breakers to operate and cut out the faulty feeder without opening the other feeders; that is, without shutting down the substation.

However, the economic disadvantage of the radial system remains, and an effective *selective feeder relay*, which could be relied upon to pick out the faulty feeder and no other, would offer material advantages.

Such a selective device is afforded by the use of *pilot cables*. Each cable or feeder is duplicated by a smaller low-voltage three-phase cable, which joins the secondaries of current transformers connected into the two ends of the main cable. If the main cable is undamaged, the same current comes out of it as flows into it, and the connections to the pilot cable are such that in this case the secondary currents would be in opposition; that is, neutralize each other. If, however, the main cable grounds, current flows into it from both sides, the secondary currents in the pilot cable then add, and the current flowing in the pilot cable operates the relay which opens the circuit breaker. This arrangement is very perfect in operation, capable of cutting out the damaged cable whether feeder cable or tie cable, without interfering with any other cable, but it has the formidable disadvantage of doubling the number of cables required in the system, and, while the pilot cables are small and of low voltage, they occupy room in the underground ducts which carry the electric circuits in American cities. Thus this method of control by pilot cable is, due to its high cost of installation, very little used in this country.

Another method is that of the "*split conductor*" cable. Every cable conductor is made of two parts, of which the one surrounds the other concentrically, with some insulation between them. Normally there is no potential difference between the inner and the outer half of the conductor, as they are connected with each other at the ends of the cable. If, however, a ground occurs on the cable, this ground can at first reach only the outer half of the conductor, and a potential difference and current appears between the inner and outer half of the conductor and operates the circuit breakers, through a relay connected between the two halves of the conductor, at either end of the cable.

This method also works very satisfactorily, but has the same economic disadvantage, though to a lesser degree than the method of pilot cables, in that the split conductor cable is materially larger and more expensive than the standard cable. It is therefore used to a limited extent only.

The usual method of taking care of the problem, at least in most cases, is by the so-called "*reverse power relay*," also wrongly called "reverse current relay."

When a cable grounds, the current at its end reverses; that is, flows into the cable ("feeding back") instead of coming out of it. However, this reversal of current by itself can do nothing, as it is an alternating current, and as such has no direction of its own, but only a relative direction to other alternating waves, as that of the voltage. Installing then a wattmeter relay at the end of the cable—that is, a relay operated by the action of two coils upon each other, the one coil energized by the current, the other by the voltage: if the current reverses, the voltage remaining the same, the pull of the relay reverses, and thereby closes the operating circuit, which opens the circuit breaker which disconnects the cable.

Such reverse power relay operates perfectly so long as there is any voltage for the reverse current to act upon. If, however, a short circuit occurs at or close to the substation, the voltage vanishes, and with it the reverse power relay loses its pull. To guard against this, the installation of reactances is recommended between cables and substations to give a sufficient voltage drop to operate the relay. However, this is an additional complication.

The reverse power relay is not adapted to guard tie feeders between stations, as in these the current reverses in direction with the change of the distribution of load between the substations.

Thus the reverse power relay does not make the operation of interconnected networks of substations possible, but in the radial system of operation, which is generally used, it is the only device which is generally available economically, and is very satisfactory, with the only exception—which must be realized—that it cannot operate where there is no voltage left.

In overhead transmission systems and networks the problems of selectivity are essentially the same as in underground cable systems, except that in interconnected networks of distributed generating power the high impedance of the lines often gives an automatic partial selectivity, which cannot exist with the low impedance of cable systems.

Interference by *lightning* with high-potential transmission lines has rather decreased with increasing line

voltage, and this is very fortunate when considering the enormous extent of these systems and the resulting certainty of lightning effects. In the present high-potential transmission lines voltages have been reached comparable with the voltage of lightning disturbances; possibly not with the voltage of the direct lightning stroke—but direct strokes into lines are rare—but few lightning-induced voltages reach beyond the insulation strength of modern high-voltage lines. In 100,000 volt lines the insulators are tested for one minute at 200,000 to 250,000 volts, and stand momentarily, for the very short time of lightning, over half a million volts. Thus it is rare that lightning flashes over or punctures the suspension insulators of our very high-voltage transmission systems. A flashover, with the grounded Y system, shuts down the circuit, often without any damage, while with the isolated delta system it may not even shut down the circuit, but is taken care of by the protective device against flashovers, the arcing ground suppressor in the station. Most lightning voltages incapable of destroying the line insulation run along the line until their energy is dissipated or they reach a station, and there they often do serious damage. The most important problem of lightning protection thus has become the rapid damping out of line disturbances caused by lightning, so as to make them harmless before they reach the station. The most effective method heretofore is the overhead ground wire. By its screening effect it lowers the voltage which lightning can induce in the line, but far more important is its powerful damping effect on the line disturbance, the traveling wave caused by lightning, which runs toward the station. As short-circuited secondary to the line wire, the ground wire absorbs and dissipates in its resistance the energy of the traveling wave, and causes it to die out at a rate several times more rapid than is the case in a line which is not protected by ground wire.

Far more destructive than the energy of lightning may be the *internal energy* of the system. While a lightning stroke may amount to millions of horse-power, at a duration of a millionth of a second, this means only thousands of foot-pounds. In a transmission network of thousands of miles extent a surge of the system may amount to many thousands of horse-power. But even a surge of a hundred horse-power only is liable to be very destructive, as it may be continual, the generator power continually replenishing the surge energy, and a hundred horse-power, during one hour, means 200,000,000 foot-pounds.

Thus the foremost problem is again the protection of the system against destruction by its internal energy, and lightning is dangerous mainly by letting loose the internal energy.

Against damage by breakdown to ground, by over-voltages, effective and complete protection is given by the *aluminium cell lightning arrester*, so that the problem of over-voltage protection resolves into the economic question, how far the cost of lightning arresters is warranted by the elimination of the danger of breakdown to ground.

Impulses, high-frequency oscillations, and stationary waves are the most common other dangers.

An *impulse* is an electrical effect in which voltage and current rise rapidly—with a "steep wave front"—and then gradually taper down and die out. Such impulses are produced by switching, operation, by flash over the insulators, by induction from lightning flashes, etc. The danger from impulse voltages lies in the local piling up of voltage due to its steep wave front. Thus, for instance, when a switch is closed and 100,000 volts put onto a line at the moment of closing the switch, 100,000 volts suddenly appear in the line at the switch, while perhaps 5 feet away the line voltage is still zero. Gradually—with the velocity of light, or 188,000 miles per second—the voltage spreads over the line as an impulse. Suppose now such impulse reaches the terminals of a transformer near the source of the impulse, where its wave front is still very steep. When the full impulse voltage reaches the first transformer turn the second transformer turn is still at zero voltage, and the full voltage of 100,000 comes on the insulation between the first two turns. While the transformer winding is insulated to stand 200,000 volts to ground for one minute, and momentarily still much higher voltage, normally the voltage between adjacent turns may be only 10 volts, and with all the extra insulation between the end turns, even if we make this insulation to stand 1000 times the voltage to which it is normally exposed, it would be far below standing 100,000 volts. Thus the danger from impulses is that they produce voltages across small parts of the circuit, single turns or coils, which are often many thousand times the normal voltage existing in this part of the circuit; thus they may be far below the total circuit voltage, and thus would not discharge over the over-voltage protective devices or "lightning arresters."

Fortunately such steep wave fronts rapidly flatten out in the progress of the wave along the circuit, so that their danger is largely limited to the immediate neighborhood of the origin of the impulse.

Assuming now that we would, by a condenser in shunt to the circuit, bypass the energy of the impulse for only one millionth of a second. During one millionth of a second the impulse travels about 1000 feet, and such a very small condenser would flatten the wave front to 1000 foot length. With such a flattened wave of 1000 foot front, before full voltage appears at the transformer terminals, the beginnings of the impulse is passed over ten or more turns, and the impulse voltage thus distributes over the insulation of a number of turns, and no difficulty exists to give the end turns an extra insulation sufficient to stand the voltage.

The foremost cases of high-frequency oscillations are spark discharges from the line, arcing grounds, etc. Their danger also is the piling up of voltage in reactive devices, such as current transformers, end turns of power transformers, etc. While a current transformer may take only a few volts at the normal frequency of sixty cycles, at 10,000 times this frequency it would take 10,000 times the voltage, and then break down between turns and between terminals. Inductance to reflect the high-frequency oscillation back into the line—which can stand it—with shunted capacity, and a non-inductive, or preferably, a capacity bipath to the inductive device such as the aluminium cell, offers protection against the danger from high-frequency oscillations. The best guard against interference by high-frequency oscillations is, however, to avoid all causes which may produce them, and the foremost cause is the arc. Thus arcs, arcing grounds, spark discharges, open-air switches, etc., should be carefully avoided in transmission systems, as introducing the dangers of high-frequency disturbances. This is to a large extent a designing problem.

In apparatus capable of electric oscillation—that is, apparatus of high inductance, considerable capacity, but very low energy losses, such as high-potential transformer windings—under certain conditions *stationary waves* may occur; that is, high-frequency impulses or oscillations, coming from the outside, built up by resonance to higher and higher voltages. Such stationary high-frequency waves are extremely destructive, as their energy is practically unlimited; is given by the low-frequency power of the system. Their frequencies usually are fairly low, between 10,000 and 100,000 cycles, and therefore it is more difficult to deal with them than with the oscillations of many hundred thousands or millions of cycles.

The best protection against them is not to allow them to build up. This is done by designing the apparatus so as to give the least ability to stationary oscillations, and by dissipating their energy, and thereby limiting their voltage, by shunted resistance. To avoid excessive waste of power in such shunted dissipating resistances, a condenser of moderate capacity is connected in series with them. Such condensers practically cut off the flow of power at the low machine frequency, but permit the flow of large currents through them into the dissipating resistance at the much higher frequencies of the standing waves.

In considering the protection of modern electrical systems it must be realized that the various sources and kinds of interference or danger require correspondingly different protective devices; it would be just as unreasonabld to expect a standard type of "lightning arrester" to protect an electric system against all possible troubles as it would be to call for a single standard "safety device" which would protect a railway train against all possible dangers, from a broken rail or a washout of the roadbed to a collision or a boiler explosion.

A Safe X-Ray Tube

When the ordinary glass X-ray tube is used not only is the operator exposed to its action, but more or less of the patient is also exposed, where no action is desired, and various screens have heretofore been used for protection. To obviate this difficulty a metal tube has been devised which absorbs all rays not traveling in a certain direction, an arrangement that makes the tube comparatively safe, and makes the use of protecting screens unnecessary. The central portion consists of a brass cylinder containing an Al window through which the X-ray beam from the anti-kathode passes practically unabsorbed. The electrodes are introduced into the central brass tube through porcelain sheaths which are fitted over the ends of the tube and suitably sealed. By means of a side chamber containing charcoal the hardness of the bulb can be controlled.

Effect of Magnetic Fields on Electric Meters

From tests recently made with one type of direct-current meter it has been found that a cable carrying 600 amperes at a distance of 12 inches from the meter affected its accuracy 50 per cent on light load. The direction of the current determined whether the meter ran fast or slow. The same current with the same cable only 2 inches away, but in a different direction, had no appreciable effect on the accuracy, showing that the relative positions of the meter and cable are the governing factors. In another case a 300 ampere direct-current meter would not register on less than 50 amperes, owing to the interfering magnetic field from an adjacent conductor. Meters may also be influenced by their own leads if brought around the instrument, or by the proximity of other meters. When three direct-current meters were placed side by side, with 12 inches between centers, the accuracy of the middle meter was affected by 5 to 10 per cent on one tenth load when either of the other meters was carrying full load. To prevent this effect the meters should be placed at least 15 inches apart, the wiring arranged so that it does not encircle the instruments, and the leads run into the meter board in a horizontal manner from the left-hand side. Placing instruments near iron girders may also cause serious errors that might be avoided by carefully selecting a location. Four-pole direct-current meters were found to be less affected by stray fields than the two-pole types.

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