the surface of the oil in the tank. When the layer of foam attains this height, it closes the air tubes and stops the flow of the liquids into the mixing chamber.

A still larger apparatus of this kind has been constructed recently at the German petroleum works in Wilhelmsburg. The foam-producing liquids are contained in two large underground cisterns, whence they are forced by steam pumps into two systems of pipes so arranged that they pass near all oil tanks, storehouses and other places liable to conflagration. The two systems of pipes are connected by a number of mixing chambers from which the foam passes to a third system of pipes. The foam pipes are provided

with a number of openings from some of which efflux pipes run directly into the oil tank, while others serve for the attachment of flexible hose as required.

A number of experiments have been made with this apparatus. A quantity of benzine contained in an iron tank 30 feet in diameter was ignited and this very considerable fire was extinguished in 3½ minutes.

A smaller tank open above, was also ignited. This tank leaked and some of the benzine escaped to the surrounding ditch which is required by law, and there burned. With the aid of two lines of hose the fire was extinguished in 2½ minutes. In another

case, a fire in a cellar in which casks of benzine were stored was extinguished in 1½ minutes. In other experiments fires in a layer of tar of 1,100 square feet area, and in a masonry tank, 30 feet in diameter, containing 15 tons of petroleum were quickly extinguished. In the last case, the apparatus was set into operation five minutes after the fire was started, and the fire was got under control four minutes later. These experiments show the great value of this method of extinguishing fires and the advisability of equipping large oil tanks and the like with apparatus of this character, which is very much more effective than any other known means of fighting fire in such cases.

Louis Winslow Austin

Government Expert on Wireless Telegraphy

By William Atherton DuPuy

AMONG the extended investigations which the Navy Department has carried on in the field of wireless telegraphy, a series of particular interest has just been completed under the guidance of Dr. L. W. Austin, the government expert. The principal purpose of the series of tests performed, was to determine as nearly as possible the law which governs long-distance transmission of electric waves, or in other words, to establish the relations which connect the principal factors, such as distance, wave-length, height of antennæ, with the relative strength of the current at the sending and receiving stations. It has been known for some time that over comparatively short

ment, however, has a great advantage in this respect. In the course of the year 1910, the Navy Department carried on a series of long-distance wireless tests that represent the most exhaustive work of this character yet performed. The cruisers "Birmingham" and "Salem" and the great Brant Rock station near Boston were practically given over to these tests throughout the year. The primary objects of these experiments was to test the sending power of wireless apparatus that had been installed on the ships of the navy. Dr. Austin, who is in charge of the United States Naval Wireless Laboratory, took part in these tests, and studied results with relation to the possi-

L. Cohen, of the National Electric Signaling Company, discovered that the quantity A is related to the wave-length by the simple law:

$$A = \frac{a}{\sqrt{\lambda}}$$

Where $a = 0.0015$ for day transmission.

Again, the quantity K itself depends both on wave-length λ and the heights h_1 , h_2 of the sending and receiving antenna, being in fact proportional to the product of these two heights. It is, of course, also proportional to I , the current at the sending antenna. The relations in question are fully expressed in the formula:

$$I_R = 4.25 \frac{I_S h_1 h_2}{\lambda d} e^{-\frac{0.0015 d}{\sqrt{\lambda}}}$$

In this equation the currents are given in amperes, and all lengths are in kilometers. The formula has been tested for sending currents from seven to thirty amperes, antenna heights 37 to 130 feet, wave-length from 300 to 3,750 meters, and distances up to 1,000 nautical miles.

Dr. Austin has constructed the actual day curve, taking into account the absorption, wave-length, etc., and has placed this beside the theoretical curve, which merely estimates the loss of intensity as proportionate to the distance. A typical curve is shown below:

DR. LOUIS WINSLOW AUSTIN.

Government Expert on Wireless Telegraphy.

distances, the current falls off approximately in inverse ratio with the distance. It is, however, known that in addition to this decrease in simple proportion, there is a further diminution of the nature of an absorption factor. The experiments carried on under Dr. Austin's directions relate to transmission over water and by day, and under these circumstances, it was found that the absorption factor takes the form e^{-Ad} where e is the basis of natural logarithms, A is a constant for a given wave-length and d is the distance. We shall return to this point presently.

Studies in wireless telegraphy on a scale capable of leading to important and new results, are hardly within the reach of the ordinary experimenter. Such a study requires more material and means than a private operator ordinarily commands. The govern-

bilities of deducing fundamental laws.

As has already been indicated, the law of absorption, stated in its simplest form, is expressed by the equation:

$$I_R = \frac{K}{d} e^{-Ad}$$

in which I_R represents the received current at the antenna (through 25 ohms), and K is a constant for a given height of antennæ and a given wave-length. Expressed in words, this equation states that the received current is in first approximation inversely proportional to the distance, while the effect of absorption shows itself by the introduction of the damping factor e^{-Ad} . The quantities K and A which enter into the above equation, are capable of further analysis. Dr.

"Day Curve" Calculated by Dr. Austin's Formula. The crosses indicate the corresponding observed values.

The experiments were carried out with flat lengths antennæ ranging in height from 30 to 80 feet, and with wave-lengths of approximately 1,500 to 4,000 meters. They indicate that for the highest efficiency of a flat-top antenna, the vertical lead wires should be bunched, so as to reduce their capacity as much as possible and concentrate it at the greatest height. Dr. Austin finds that for good communication 4×10^{-9} watts must be received at the antenna, while for audible signals 2.5×10^{-9} watts is necessary.

In securing the observations upon which these findings were based, the "Birmingham" and the "Salem" were sent on various cruises from the Brant Rock station in various seasons of the year. These cruises extended as far as Liberia and to a point in the Atlantic near Porto Rico. The distances of the observa-

tions varied from 20 miles to more than 1,000 miles. Messages were sent night and day from all the distances between those figures, and a multitude of detail accumulated from which to make deductions.

The value of these formulæ is in their application to the actual work of wireless telegraphy. They lay down a scale by which may be figured the necessary height of antenna, and the necessary current in getting desired results. They give a basis for figuring the distance that may be reached with a given antenna and a given current. If the government desires to establish two stations a thousand miles apart, it will know the size and strength necessary in those stations to get results. It can estimate the distance that may be reached by the stations already established or by the wireless apparatus already installed on its battleships. The same information is also at the disposal of all those private wireless companies that have hitherto worked somewhat in the dark.

The government, for instance, has been considering the establishment of wireless communication between Honolulu and San Francisco. It is intended to attempt this in the near future. We here have definite information upon which to proceed. The government has also decided upon the establishment of a wireless station of great strength at Fort Myer, near Washington. Here three towers are to be erected. One of these is to be 600 feet high, one of the tallest structures in the world. The others are to be 450 feet high. The antenna is to be strung between these towers. It is the ambition of the government to reach out with this station to practically the whole of the Atlantic ocean and be prepared to order its ships hither and thither at a moment's notice. It is estimated that the great station will be able to send a message 2,000 miles with a reasonable dependence upon its being delivered. The new findings of the navy's expert will aid greatly in the carrying out of all these plans.

An example of the possibilities of exact calculation of the distance that may be reached by a given current as between two ships with an antenna height of 130 feet is shown in the following table:

Antenna Current I _a	λ = 1000 m			
	Working Distance 40.10 * amp.		Extreme Distance of Audibility 10.10 * amp.	
	Day	Night (Zero Absorption)	Day	Night (Zero Absorption)
1 amp.	75 miles	90 miles	200 miles	360 miles
2	135	180	300	720
3	180	270	375	1080
5	225	450	475	1800
7	280	630	550	2520
10	345	900	620	3600
15	420	1350	725	5400
20	475	1800	790	7200
25	525	2250	840	9000
30	565	2700	900	10800
40	630	3600	970	14400
50	685	4500	1025	18000
60	725	5400	1150	21600

With two stations with flat-top antennæ 450 feet high, such stations as might be constructed in San Francisco and Honolulu in the proposed attempt to establish communication, a table like the following might be expected to accomplish results. As the distance between San Francisco and Honolulu is about 2,000 miles, it appears that easy communication may be established.

Nautical Miles	λ = 1000 m	λ = 2500 m	λ = 3750 m	λ = 6000 m
	15 amp.	13.5 amp.	15 amp.	17 amp.
1000	38	27	27	30
1250	51	36	36	40
1500	61	43	44	46
1750	71	50	51	54
2000	80	57	58	61
2250	89	64	65	68
2500	97	70	71	74
2750	105	76	77	80
3000	112	82	83	86

In addition to all this, Dr. Austin has worked out elaborate tables as a basis for figuring out all these problems with reference to wireless stations existing and prospective. These tables are being prepared for publication by the government, and are to be given freely to the world. They will be of inestimable value to all working in wireless telegraphy. They will put the whole science on much more nearly a quantitative basis. The whole of these results will soon be obtainable upon application.

Dr. Austin had done much valuable work in wireless before his present experiments. Since 1904 he has been connected with the government Bureau of Standards, where one of the greatest bodies of scientific men in the world is stationed, and where much of advanced scientific work with a bearing on governmental affairs is being prosecuted.

Among other achievements of Dr. Austin may be mentioned his invention of a contact rectifier, which is in various forms now used in a large proportion of wireless stations in the United States.

Dr. Austin had been an instructor in the University

of Wisconsin, and has been in the service of the German government in scientific work. His education was completed in Germany, and he has become recognized as one of the authorities in electrical work on two continents. He is still busy in his laboratory work for the government, and feels that the possibilities of further discoveries in wireless telegraphy are great, and is confident of vast improvement in such transmissions in the future.

The Indian Tea Industry

By EDWARD F. HARRAN, Calcutta Port Commission.

SOMETIME in the early part of the nineteenth century the tea plant (*Camellia theifera*) was discovered growing wild in Assam, a great province in the North East of British India, and, as a result, its cultivation, at first on a small, but on a gradually extending scale, was begun. In the year 1841 the first sale of Indian tea was held in London, it being on record that some 2,000 packages were offered and disposed of. Since that year the number of acres growing the tea plant has steadily extended, while exports of the article have increased proportionately until, at the present day, the trade has assumed proportions which outrival those of any other industry in the country. The principal districts in India producing tea are Darjeeling, the Dooars and the Terai in the vicinity of the north-eastern extremity of the Himalayan Mountains; Chitragong Hill Tracts, on the East of India; the province of Assam on the North East and the adjacent districts of Cachar and Sylhet. In the Darjeeling district the plant is to be found flourishing at an altitude of between 7,000 and 8,000 feet above sea level, and although the bush does not attain such large dimensions here as it does in the low-lying parts of Assam and Sylhet, and is far less prolific, the tea manufactured from it is usually of a very much finer flavor than that obtained from the latter districts, and commands a far higher average price both at the Calcutta and London tea sales. It would be a somewhat difficult matter for anybody but an experienced planter to name the several different varieties of the plant which are now cultivated. Possibly the two original ones were those known as *Assamica* and *Sinensis*, but there are now a number of hybrid varieties giving a large and regular crop, many of which have developed under different climatic influences.

The Indian tea crop is, as has already been said, a constantly expanding factor in the commerce of the country, having been 173,988,444 pounds in the season of 1902-1903; 197,834,338 pounds in 1903-1904; 202,864,013 pounds in 1904-1905; 202,747,357 pounds in 1905-1906; 221,176,117 pounds in 1906-1907, and 213,722,195 pounds in 1907-1908. (The slight decrease in the latter year as compared with the year immediately preceding it was due to the failure of the monsoonal rains in certain districts.) This output is handled mainly in two different ways. A proportion of it is consigned from the gardens of origin directly to the two Indian ports which export tea, Calcutta and Chittagong, and shipped directly from there either to London, New York or other countries in which the assignment is destined to be consumed. The remainder of the crop is railed or boated from the gardens to Calcutta, where it is sold at periodical auctions and disposed of by the buyers either to local consumers or shipped to over-sea marts. The following table shows the various parts of the world, other than the United Kingdom, which India teas were shipped to directly from Calcutta during the season 1907-1908, together with the approximate quantity so dealt with:

Europe—	Pounds.
Antwerp	73,205
Batoum	4,841,454
Bremen	261,285
Christiana	5,464
Constantinople	345,154
Copenhagen	5,508
Hamburg	369,625
Havre	25,785
Marseilles	9,971
Odessa	941,939
Rotterdam	103,429
Trieste	60,701
St. Petersburg	90,869
Salonica	2,400
Samsoun	2,585
Moscow (via Vladivostok)	2,235,461
Other ports	59,068
Total	9,433,894
Asia—Total	18,312,689
Africa—Total	743,430
America—Total	3,744,298
Australia—Total	10,950,982
Grand total	43,185,293

In addition to the above, during the same season 1907-1908, 9,098,504 were shipped from Calcutta to other Indian and Cingalese ports, principally Colombo.

Turning to tea handled in Calcutta itself, it may be stated that with the increase in the output of the gardens and the consequent rapid expansion of trade, there existed for many years a notable need for concentrating it in some portion of the city where it could be handled with facility and the chests expeditiously disposed of. This need was first met by the commissioners for the port of Calcutta making over one of their warehouses on the bank of the River Hooghly for the concentration of the trade, and in which the periodical tea auctions could be held. This sufficed for some years, but the rapid expansion of the industry soon outgrew the limits of that building, and in 1904 the commissioners, on the representations of the trade, resolved to build a special warehouse and equip it upon thoroughly up-to-date and model lines. The sanction of the government of India was necessary to the proposal, and it was May, 1905, before this was received. Work was at once taken in hand, the projected warehouse being designed by Mr. Frederick Palmer, C.I.E., A.M.I.C.E. (Eng.), the Chief Engineer of the Calcutta Port Commission and now Engineer-in-Chief of the Port of London, and Mr. John Scott, A.M.I.C.E. (Eng.), then District Engineer of the Calcutta Port Commission, now Chief Engineer of it. The whole of the brick and stone work of the building was constructed by the Port Commissioners' own labor, the iron work and the installation of the electric lifts being done by contract with private firms. The edifice consists of four stories, each carried on substantial rolled steel joists and supported on built-up columns of heavy section steel girders. Each floor is divided into three large warehouses, separated by solid masonry walls 20 inches thick, communicating with one another by means of fire-proof doors. The foundation work, which was rendered exceedingly difficult owing to the founts having to be laid across two old slip-ways (which necessitated a large amount of pile driving), is entirely of reinforced concrete. The whole structure measures 526 feet in length, by 122 feet in width, has a uniform height of 52 feet 8 inches, and comprises 436,300 cubic feet of brickwork alone. The warehouse was specially designed to facilitate the easy and rapid handling of large quantities of tea. One side of it abuts onto the banks of the River Hooghly, adjacent to which two commodious sheds, known as the Tea Transit Sheds, have been erected, and from and to which steamers can directly receive or discharge chests. On the other side, the permanent way of the railroad has been laid, and loaded freight cars are thus brought up right alongside the warehouse and their contents are discharged directly into it; from the bottom floor the chests of tea are conveyed to the higher stories by specially constructed electrically-driven lifts, of which there are eighteen in all. Basing the calculation on a cost of 2½ annas¹ per unit of electrical energy expended, it is estimated that the entire cost of operating these eighteen lifts is only about 323 rupees² per mensem, and this is in spite of the fact that the lifts work an average of over fourteen hours a day, and frequently, during the height of the tea season, seven days a week. Each lift has been tested to a working load of 30 hundred-weight, is designed for a speed of 90 feet per minute, and depends for its power on a 20 brake-horse-power electric motor, situated on the top floor of the building, running at 800 revolutions per minute. A feature of the warehouse is the tea bulker, which works in connection with a tea mixer having a capacity of sixty-four chests of tea, situated on the second floor. The tea is fed into this mixed over the sides, and passing through the floor by a huge funnel in which it is mixed runs through the apex of this into four hoppers on the floor below. The cost of the entire tea warehouse and its equipment, including the railway sidings, was nearly nine and a half lakhs of rupees.³ The total amount of tea that changed hands under the auctioneer's hammer in the warehouse during the season 1907-1908 was 73,176,885 pounds, while the total quantity that actually passed through it during the same period was 1,449,540 chests, or, at 95 pounds to the chest, 137,706,300 pounds, out of a total crop in India of 213,722,195 pounds. It will be seen, therefore, that it is no misnomer to call the warehouse the "center of the India tea trade." In conclusion, some little idea of the magnitude of the industry may be culled from the statement that the average value of the annual production of Indian tea is about six million pounds sterling, that of China about five and a half million pounds sterling and that of Ceylon between three and four millions.

¹ An anna equals one penny in English coinage and two cents American.
² A rupee equals one shilling and four pence in English coinage and about thirty-two cents American.
³ A lakh of rupees equals \$6,333 in English coinage and about \$31,660 American.