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GENERAL INFORMATION

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INSTITUTE ACTIVITIES

Meeting of Board of Direction

At the meeting of the Board of Direction held in the offices of the Institute on September 7, 1927, the following were present: Ralph Bown, President; Melville Eastham, L. A. Hazeltine, R. A. Heising, J. V. L. Hogan and J. M. Clayton, Assistant Secretary.

The Board approved the action of the Committee on Admissions in the case of the following applications: transfer to the grade of Fellow, Pendleton E. Lehde and H. E. Hallborg; transfer to the grade of Member, Ernest V. Amy, C. C. Harris, Harold Herbert, Ross A. Hull, and W. A. Thomas; election to the grade of Member, W. H. Bailey, T. W. Bearup, R. B. Owens, and John Murchie.

Eighty-four Associate and eighteen Junior members were elected.

During the months of July and August two hundred and thirty-seven Associate and thirty-nine Junior members were elected.

The Board approved the application from members residing within the vicinity of Buffalo for the formation of a Buffalo-Niagara Section of the Institute.

New York Meeting of the Institute

At the first Fall New York meeting of the Institute, held on September 7th in the Engineering Societies Building, 33 West 39th Street, New York, a paper by Messrs. H. Diamond and J. S. Webb was presented by Mr. Diamond. The subject was, "The Testing of Audio-Frequency Transformer-Coupled Amplifiers."

The following took part in the discussion which followed the reading of the paper: Professor L. A. Hazeltine, R. R. Batcher, George Crom, I. G. Maloff, Melville Eastham, and others.

The attendance at this meeting was over three hundred.

News of the Sections

Practically all of the Sections are making plans for resumption of activities for the Fall season. All of the Sections have meetings planned for the month of September.

Those Sections requiring them are now being supplied with preprint copies of all papers which are to be presented before the New York meetings. In most cases these papers will be available for Section use several weeks prior to the New York meetings. Sufficient preprints are being supplied for each person attending each Section meeting to secure one at the meeting.

Committee Work

At the meeting of the Committee on Admissions held on the afternoon of September 6, 1927 in the offices of the Institute, the following were present: Professor L. A. Hazeltine (Acting Chairman) and Messrs. R. A. Heising and H. F. Dart.

The Committee acted upon thirty-five applications for transfer or election to the grades of Fellow and Member.

Fourteen Year Index

Printing of the fourteen year Index to the PROCEEDINGS has been held up unavoidably. It is hoped that this Index will be in the mails shortly after the October issue is published. When completed, each member of the Institute will be mailed a copy of the Index.

The price to non-members will be one dollar.

LONG-WAVE RADIO MEASUREMENTS AT THE BUREAU OF STANDARDS IN 1926, WITH SOME COMPARISONS OF SOLAR ACTIVITY AND RADIO PHENOMENA*

By

L. W. Austin

(Laboratory for Special Radio Transmission Research conducted jointly by the Bureau of Standards and the American Section of the International Union of Scientific Telegraphy).

The following is a résumé of the measurements made by the Bureau of Standards on long-wave signal intensities and atmospheric disturbances during 1926, to which have been added some

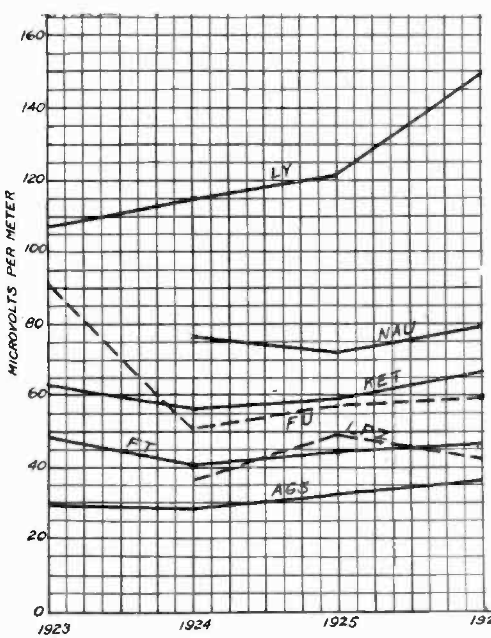

Fig. 1—Annual Average Signal, 10:00 A.M.

measurements from former years for the purpose of studying the relations of radio transmission and atmospheric disturbances to other natural phenomena.

Received by the Editor, July 12, 1927.

Read before the International Union of Scientific Radio Telegraphy, American Section, April 21, 1927.

* Published by Permission of the Director of the National Bureau of Standards of the U. S. Department of Commerce.

The method of measuring weak signals through heavy atmospherics, described in the report for 1925[1] in which a correction factor for the deadening effect of the atmospherics is determined by measuring the apparent strength of a correspondingly weak artificial signal, with and without atmospherics, has proved entirely successful.

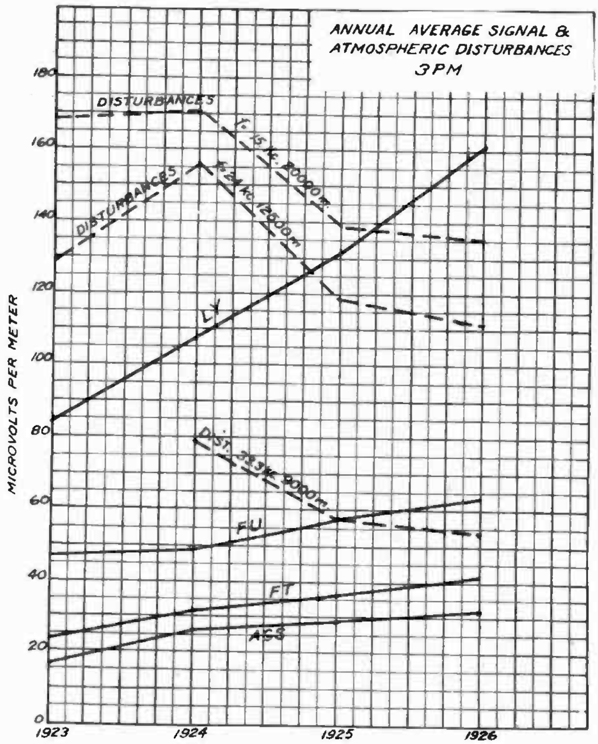

Fig. 2

On account of the lack of assistants in the laboratory for taking night and holiday observations, much time has been devoted by my assistant, Mr. Judson, to experiments on automatic measuring apparatus. At the close of the year these experiments had so far progressed that regular 24-hour records were being made of the Bordeaux, Tuckerton, and Cape Cod signals and atmospheric disturbances, using a high antenna for Bordeaux and a lower one for the American stations. A Cambridge-Paul recorder is being used which records at every half minute for five minutes in each

[1] Proc. I. R. E., vol. 14, p. 663; 1926.

hour on each station being measured, the antenna and secondary circuits being changed in tune by means of a clock-controlled relay and secondary relays. The capacity of the system will permit further stations to be added when it seems desirable. It is, of course, not expected that European stations can be recorded during the summer without interruption from atmospherics. Apparatus is also being developed for recording the direction of atmospherics.

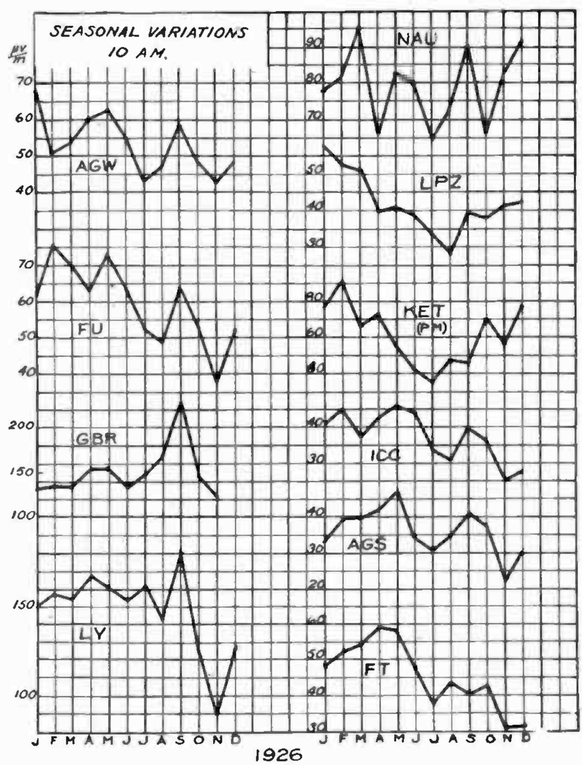

Fig. 3

The tables and Figs. 1 to 4 are similar to those given in former reports and are in general self-explanatory. The daylight strength of all the stations shown, except LPZ, has continued to rise during 1926 while the average daylight atmospheric disturbances have continued to fall.

Fig. 3 shows the seasonal variations of the 10 A.M. (E.S.T.) all daylight signals of various stations. Practically all these stations show a peak in the curve of monthly averages in September or October, while the European stations show low values in November and generally in December and January. A number of stations also have peaks at some time in the spring. The north-south stations NAU (Porto Rico) and LPZ (Argentina) do not show the late autumn and winter minima nor does KET (Bolinas, Calif.) (3 P.M.)[2] although its transmission is west-east. This confirms our earlier surmise that the low autumn and winter signals of the European stations are due to the proximity of the European sunset to the transmitting time of the signals received at 10 A.M. The September or October peak may possibly have some significance. It is conceivable that it may have some connection with the autumn peak of the curve of terrestrial magnetic range.

TABLE I

Average Signal Intensity and Atmospheric Disturbances for Lafayette (LY), Ste. Assise (FU) Nauen (AGW), Rugby (GBR), Monte Grande (LPV) and Rio de Janeiro (SPR), in microvolts per meter.

	A. M.							P. M.						
1926	LY	FU	AGW	GBR	LPV	SPR	Dist.	LY	FU	AGW	GBR	LPV	SPR	Dist.
January	150	62	68	134	—	—	34	240	91	116	—	—	—	48
February	157	76	51	136	—	—	32	186	65	72	170	—	—	54
March	156	70	54	137	—	—	38	203	83	63	159	—	—	59
April	168	63	60	156	—	—	65	174	73	53	129	—	—	96
May	162	74	62	155	51	—	41	144	59	46	127	31	—	148
June	154	63	56	134	42	—	40	109	45	40	94	25	—	176
July	161	52	44	145	31	40	40	113	42	32	110	—	—	232
August	142	49	47	165	27	36	44	96	40	39	107	15	30	435
September	181	64	59	230	38	38	34	142	47	42	181	—	18	209
October	124	54	49	145	33	36	39	122	58	53	152	34	27	82
November	90	37	43	122	29	37	39	148	58	55	149	27	30	54
December	129	52	49	—	34	43	27	256	110	89	310	—	37	37
Average	148	60	54	151	36	38	39	161	64	58	154	26	28	136

Last year much time was devoted to a study of the observational data of the laboratory in regard to a relationship with temperature and this relationship was quite definitely established as far as stations at moderate distances are concerned.[3]

At present the relationships of radio phenomena to solar activity and terrestrial magnetism are being examined. Some preliminary results of this study are here given.

Solar Activity and Radio Phenomena

It has been often suspected that a connection exists between radio and the aurora and magnetic storms. The connection with magnetic storms was first definitely established by Espenschied, Anderson and Bailey[4] in the work of the Bell Telephone Company in preparation for the establishment of a transatlantic telephone

[2] The 3 P.M. signals from Bolinas are given instead of those at 10 A.M. as these give better all daylight conditions.

[3] Proc. I. R. E., vol. 14, p. 781; 1926.

[4] Proc. I. R. E., vol. 14, p. 7; 1926.

service. They found that magnetic storms greatly decreased the strength of night signals and slightly increased the daylight strength. This effect was more pronounced at a wave length of 5000 m. than at 17000 m. Since terrestrial magnetism is known

TABLE II

Average Signal Intensity and Atmospheric Disturbances for Ste. Assise (FT), Bolinas (KET, Nauen (AGS), Monte Grande (LPZ), Leafield (GBL) and Coltano (ICC) in microvolts per meter.

	A. M.							P. M.						
1926	FT	KET	AGS	LPZ	GBL	ICC	Dist.	FT	KET	AGS	LPZ	GBL	ICC	Dist.
January	48	72	33	57	20	41	27	54	76	47	43	22	—	39
February	53	70	40	53	31	45	27	54	91	41	36	20	—	44
March	55	69	40	51	25	37	33	56	68	40	31	19	—	47
April	60	71	42	40	27	43	57	49	71	34	33	22	24	84
May	59	76	47	41	23	46	33	38	55	27	17	15	31	129
June	48	62	35	39	21	44	35	21	41	21	15	12	22	153
July	39	57	31	34	16	34	34	25	36	17	17	15	21	192
August	44	—	35	28	14	31	42	27	48	22	28	—	23	369
September	42	58	42	40	20	40	27	26	47	—	—	14	24	128
October	43	67	37	38	24	36	34	39	70	31	27	21	29	72
November	32	63	23	41	15	25	29	48	59	37	32	20	36	44
December	32	65	31	42	16	27	20	56	78	38	42	20	44	29
Average	46	66	36	42	21	37	33	41	62	32	29	18	28	111

to be closely connected with solar activity a similar connection of solar activity and radio signal strength was to be expected, and Pickard, in a recent paper,[5] has shown that such a relationship exists.

Rough observations on signal strength by the shunted telephone method were begun in this laboratory in 1915, and on the strength of atmospherics a little later, while since 1922 measure-

TABLE III

Average Signal Intensity and Atmospheric Disturbances for El Cayey (NAU) in microvolts per meter

	A. M.		P. M.	
1926	NAU	Dist.	NAU	Dist.
January	78	13	69	15
February	81	13	70	20
March	96	17	65	21
April	66	29	51	42
May	83	17	54	71
June	80	18	51	80
July	65	17	41	112
August	72	23	61	147
September	91	16	57	80
October	66	15	65	30
November	83	14	54	19
December	92	11	83	13
Average	79.6	16.9	60.1	54.4

ments of these quantities have been made which have considerable accuracy. These observations, which were originally planned for the purpose of making comparisons with other natural phenomena furnish considerable material for the present study.

In Fig. 5 the annual averages of sunspot numbers and the all daylight reception from Nauen in Washington from 1915 to 1926 is seen. The earlier years of the Nauen reception curve have little

[5] Proc. I. R. E., vol. 15, p. 83; 1927.

claim to accuracy but it is certain that there was a reception maximum in 1917 and low values from 1920 to 1924. The signals are reduced to uniform antenna current.

Fig. 6 shows the relationship between the monthly average sunspot numbers and the monthly average strength of the all daylight signals from Nauen covering a period of five years from 1922 to 1926 inclusive. In order to eliminate the effects of seasonal variations on the signal strength, the observational points on the curve are the deviations from the means of the same months for the five years.

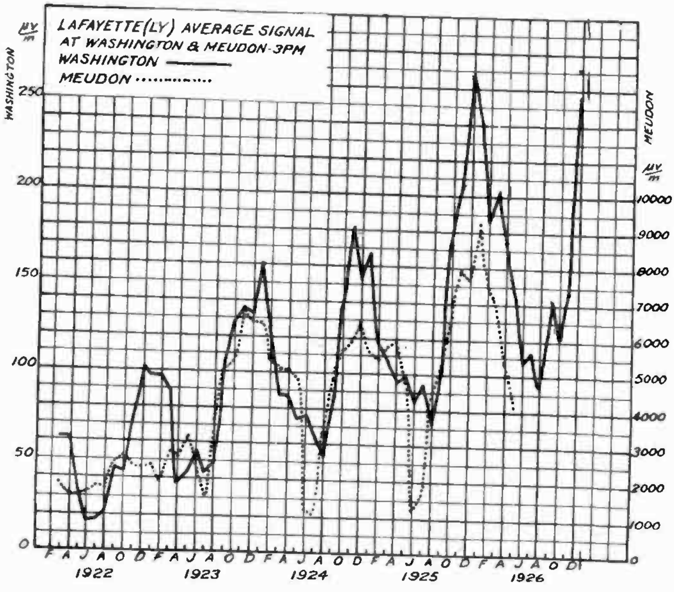

Fig. 4

Fig. 7 shows a similar curve for the averages of a number of stations, from 1924 to 1926. These curves of sunspots and signals, while not following each other exactly from month to month, show a quite definite positive correlation between solar activity and strength of long wave daylight radio transmission averaged over long periods.

Thus far our conclusions are reasonably certain, but in what follows I feel that we are on much less secure ground.

If the existence of a correlation between solar activity and radio be accepted, it is natural to suppose that there may be variations in radio reception which may show a connection with

TABLE IV

Miscellaneous Observations on Signal Intensity in Microvolts per Meter

1926

	AXL	AGX	GB	IDG	LCM	MUU	NPL	NBA	PCG	SAQ	YN	AFL	NPG	GKB	FZ	IDO
January	44.4	30.0	—	33.0	23.5	43.0	—	27.3	70.5	30.0	—	6.0	—	8.3	—	—
February	40.6	24.2	78.0	51.0	29.1	37.2	41.3	30.6	73.2	34.8	32.0	5.5	—	3.0	4.0	—
March	38.7	26.2	76.8	—	22.4	31.6	65.5	31.8	62.1	33.8	27.3	6.0	32.0	4.2	3.0	—
April	49.7	31.5	57.0	—	20.6	—	47.0	29.7	61.5	46.2	30.0	4.0	—	5.0	4.0	—
May	46.8	27.8	49.2	36.0	25.6	28.2	44.3	31.3	62.5	42.8	24.1	4.0	—	—	—	—
June	41.3	26.2	51.5	38.4	18.2	27.2	50.1	32.1	58.0	39.3	23.1	3.3	28.6	—	—	15.0
July	34.9	22.0	43.0	36.9	14.2	24.1	57.3	22.8	56.1	32.3	20.5	—	22.6	—	—	10.6
August	31.5	21.5	40.5	30.0	15.0	22.7	34.3	22.0	56.0	28.5	18.2	—	—	—	—	—
September	30.0	30.4	47.5	45.6	14.6	18.5	54.0	—	54.0	28.5	15.0	—	—	—	—	—
October	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
November	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
December	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Average	39.7	26.6	55.4	38.7	20.3	26.5	49.3	28.4	61.5	35.3	23.7	4.8	—	—	—	—

the period of rotation of the sun. It would not of course be expected that the changes in strength of reception would regularly follow the solar rotation, but if the irregular terrestrial factors could be eliminated, it might well be that, on an average, a waxing and waning of the signal strength would be found as the sun rotates.

When it is suspected that observed values may have a tendency to vary in a definite period, one of the best methods of handling the data is to divide the observations into groups of days equal to the suspected period, and then average the corresponding observations of the successive groups. By this process the real

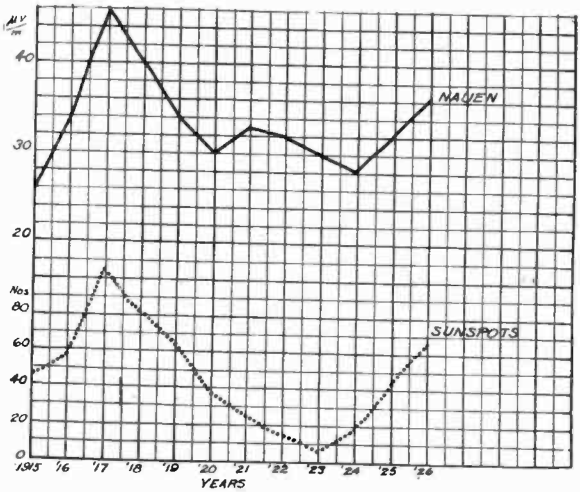

Fig. 5—Annual Average Signal Intensity of Nauen (AGS), 10:00 A.M. and Sunspot Numbers.

periodic changes should build up while others should tend to cancel. The apparent time of solar rotation is somewhat indefinite since the surface of the sun is gaseous. At the solar equator, the rotation period is about 25 days, at a latitude of 75 degrees, it is 32 days, while in the region where the sunspots are most numerous, it may be taken approximately as 27 days.

In Figs. 8 and 9 the signal field strength deviations from monthly averages have been divided into successive periods of 27 days, and the periods averaged, all the first days of all the periods, then all the second days and so on. Fig. 8 shows the results of this procedure for the sunspot numbers and for the daylight signals from Nauen AGS for the three years, 1922–1924 inclusive, and also for 1925 and 1926.[6] From this figure it appears that the Nauen signals, like the sunspot numbers, vary with the solar rotation and keep persistently in nearly opposite phase to them.

Some stations like LPZ (Argentina) appear to show very little 27-day variation; while in some cases, Bordeaux for example, Fig. 9, there seems to be a strange persistence in the signal curve forms even after an interval of a large number of 27-day periods. It is interesting to note in Fig. 9 that the two curves of the first halves of the two different years are more nearly alike than the first and second halves of the same year. In this connection it

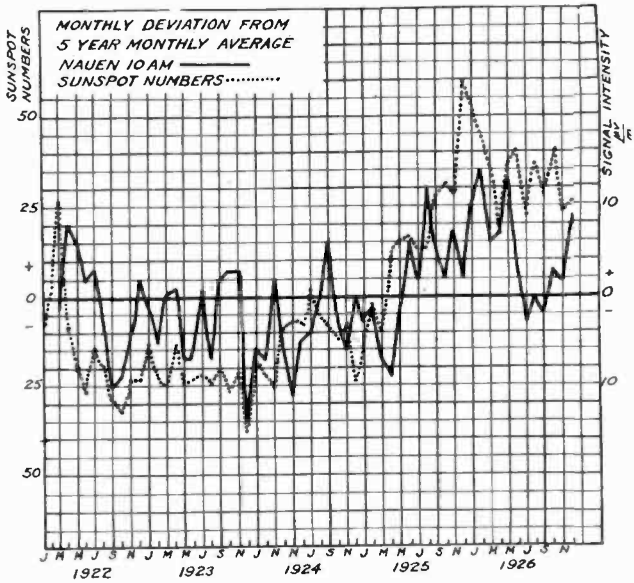

Fig. 6

may be remembered that the spots of the sun's northern hemisphere face the earth from December to June, while from June to December the southern spots face us. In addition to the 27-day periods there also seem to be indications of periodic changes in signal strength in shorter periods than 27 days. Some of the stations appear to show a 9-day period, which is one third of the period of solar rotation, while in some cases even shorter periods can be detected.

[6] For the sake of clarity the observation points in all the periodic average curves have been repeated beyond the 27-day period and in some cases smooth curves have been drawn through the irregular curves of the actual averages.

It seems scarcely possible that such detailed resemblances as are shown in Fig. 9 can represent anything real in solar and radio relations, but while they are very possibly without real significance,

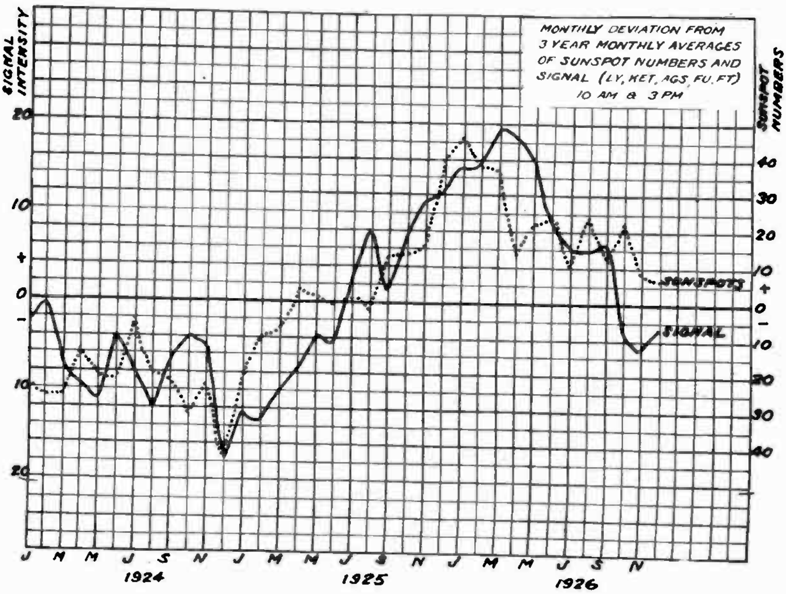

Fig. 7

the similarities are tantalizing. The continuation of these periodic changes through several years, if they are real, would indicate fixed active areas on the sun which persist over very long periods.

TABLE V
DATA FOR TABLE IV.

Station	Approximate wave length	Frequency	Location
AXL	18 300 m	16.3 kc	Warsaw, Poland.
AGX	14 500 m	20.6 kc	Eilvese, Germany.
GB	7 800 m	38.4 kc	Glace Bay, N. S.
IDG	21 000 m	14.2 kc	Pisa, Italy.
LCM	12 000 m	24.9 kc	Stavanger, Norway.
MUU	14 000 m	21.4 kc	Carnarvon, Wales.
NPL	10 000 m	29.9 kc	San Diego, Calif.
NBA	6 500 m	46.1 kc	Darien, Panama.
PCG	17 800 m	16.8 kc	Kootwijk, Holland
SAQ	18 500 m	16.2 kc	Goteborg, Sweden.
YN	15 400 m	19.7 kc	Lyons, France.
AFL	7 800 m	38.4 kc	Königs-Wusterhausen, Germany.
NPG	10 500 m	28.5 kc	Mare Island, Calif.
GKB	6 800 m	44.0 kc	Northolt, England.
FZ	10 200 m	29.3 kc	Beirut, Syria.
IDO	11 000 m	27.2 kc	Rome, Italy.

In addition to the comparisons of solar activity and signal strength, a study is also being made of possible relations between solar activity and the strength of daylight atmospheric dis-

TABLE VI
TRANSMISSION DATA FOR TABLES I, II AND III.
1926.

	Frequency	Wave Length	Antenna Current	Effective Height	Distance d
	f	λ	I	h	km
LY[a], Bordeaux	15.9	18 900	570	180	6160
FU, Ste. Assise, Paris	15.0	20 000	475	180	6200
FT, Ste Assise, Paris	20.8	14 400	380	180	6200
AGW[a], Nauen, Berlin	16.5	18 100	457	170	6650
AGS[a], Nauen, Berlin	23.4	12 800	398	130	6650
GBR[a], Rugby	16.1	18 600	653	185	5930
GBL, Leafield, Oxford	24.4	12 300	210	75	5900
LPZ, Monte Grande, Buenos Aires	23.6	12 700	600	143	8300
LPV, Monte Grande, Buenos Aires	17.0	17 600	565	143	8300
SPR, Rio de Janeiro	13.8	22 000	780	150	7800
KET[a], Bolinas, San Francisco	22.9	13 100	659	51	3920
ICC, Coltano, Pisa	19.9	15 000	380	150	7100
NAU, Cayey, Porto Rico	33.8	8 870	150	120	2490

[a] Daily antenna current reported. Other antenna currents more or less uncertain.

turbances. This will be more fully reported at another time, but the preliminary results are as follows: Here the connections are by no means so clear as in the case of the signals. A comparison of the

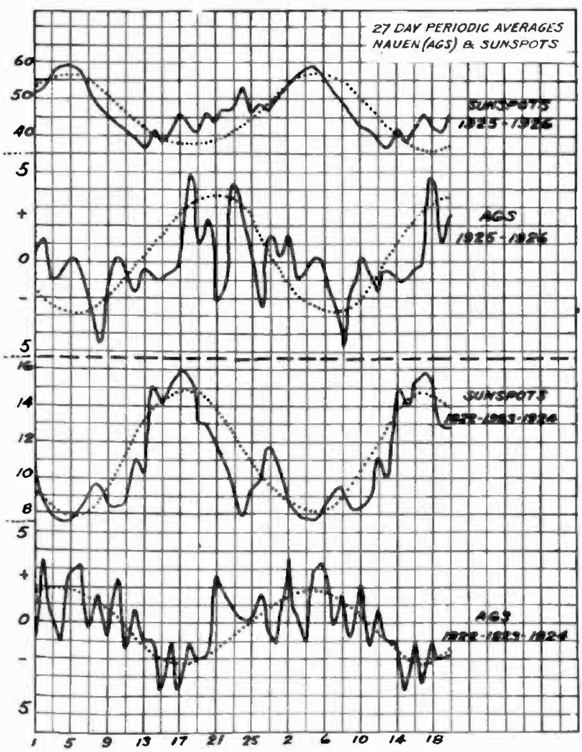

Fig. 8

monthly averages of sunspots and long wave daylight atmospherics, covering several years, shows little certain correlation between the two. If a correlation exists, it is apparently negative; that is, there has been a tendency since 1924 for the atmospherics to decrease with the increasing sunspot numbers of the advancing 11-year cycle. Twenty-seven day periodic averages also appear to show some degree of negative relation for the daylight atmospherics.

In conclusion, the observations show with considerable certainty that there is a general increase of signal strength with increasing sunspot numbers. There also appears to be a possible periodic relationship between the sunspot numbers and daylight

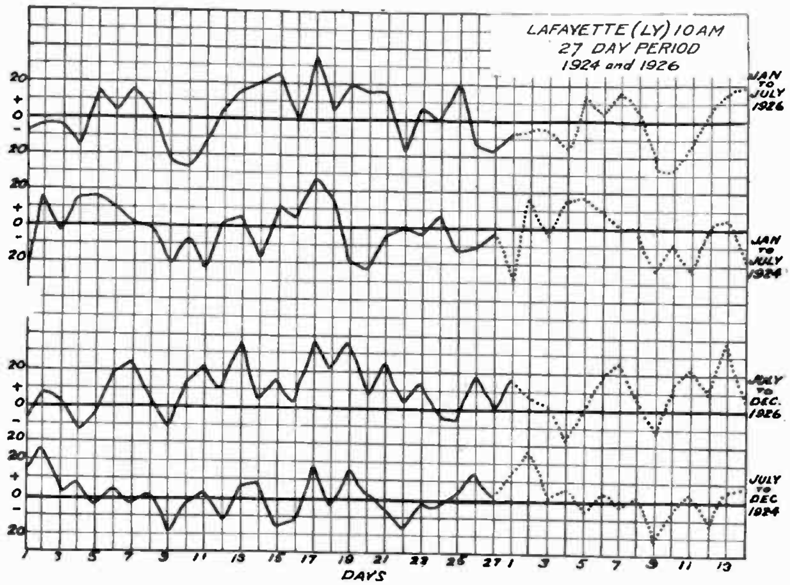

Fig. 9

signals, in which, in the case of most stations observed, the signals are nearly in opposite phase to the periodic changes of the sunspots. This is in agreement with the results of Pickard in the broadcasting range. While the work thus far must be considered to be in the preliminary stage, it seems probable that the relations of solar activity and radio phenomena will be found to be as worthy of study as those of solar activity and terrestrial magnetism.

A limited number of mimeographed copies of the Bureau of Standards record of daily signal measurements of long wave stations since January 1, 1924, are available for distribution to those engaged in the study of radio transmission phenomena.

RADIO ATMOSPHERIC DISTURBANCES AND SOLAR ACTIVITY*

By

L. W. Austin

(Laboratory for Special Radio Transmission Research, Bureau of Standards)

The suggestion that atmospheric disturbances might be due to a bombardment of the earth's atmosphere by electrified particles from the sun was first made by De Groot[1] in 1917. A number of years later the U. S. Navy began experiments looking toward the establishment of a connection between these disturbances and solar activity. It was thought that there might be such a connection in the case of the type of atmospherics which sometimes produces simultaneous disturbances in the receiving apparatus

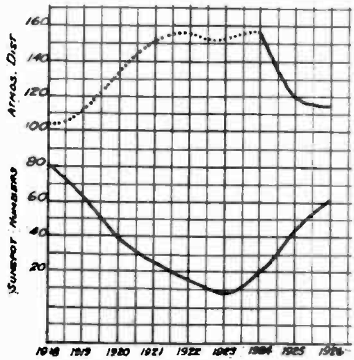

Fig. 1—Annual Average Atmospheric Disturbances, 3:00 P.M. (24 kc, 12500 m) and Sunspot Numbers.

at widely separated points as in Honolulu and San Francisco or even in Honolulu or San Francisco and Berlin.[2] There seemed to be some evidence that these simultaneous disturbances took place when the large sunspots were in the center of the sun's disk facing the earth. The observations were made in San Francisco and in

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Read before the American Geophysical Union (Section of Terrestrial Magnetism and Electricity), April 28, 1927.

* Published by permission of the Director of the National Bureau of Standards of the U. S. Department of Commerce.

[1] C. De Groot, Proc. I. R. E., vol. 5, p. 75; 1917.

[2] Baumler, Jahrb. d. Drahtlosen Teleg., vol. 19, p. 325; 1922. Proc. I. R. E., vol. 14, p. 765; 1926.

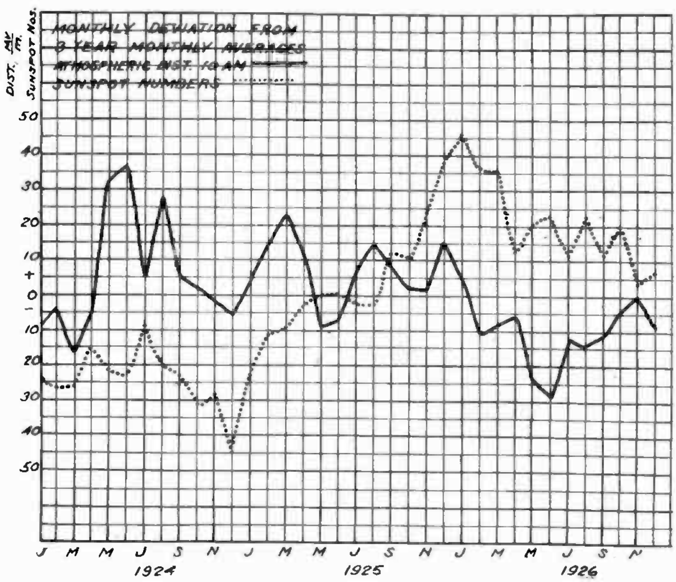
MONTHLY DEVIATION FROM
3-YEAR MONTHLY AVERAGES
ATMOSPHERIC DIST. 10 AM
SUNSPOT NUMBERS
SUNSPOT NOS.
50
40
30
20
10
+
0
-
10
20
30
40
50
J M M J S N J M M J S N J M M J S N
1924
1925
1926

Fig. 2

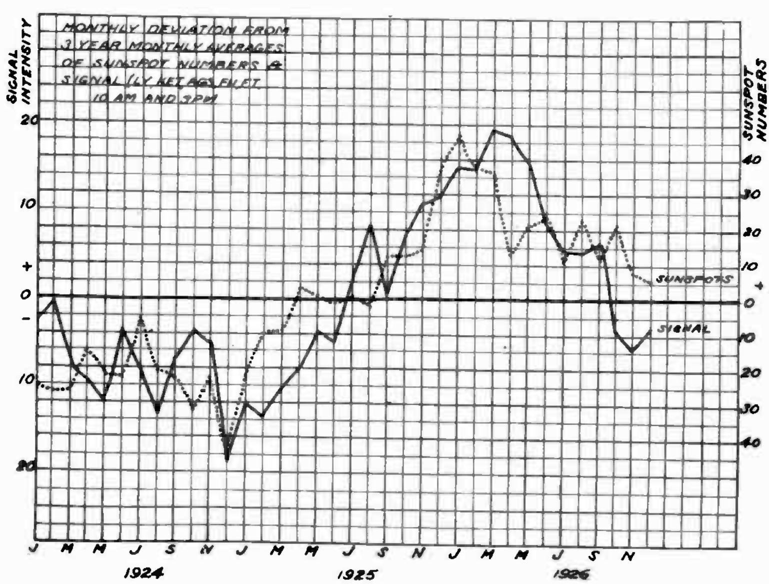
MONTHLY DEVIATION FROM
3 YEAR MONTHLY AVERAGES
OF SUNSPOT NUMBERS &
10 AM AND 3PM
SIGNAL INTENSITY
SUNSPOT NUMBERS
20
10
+
0
-
10
20
40
30
20
10
+
0
10
20
30
40
SUNSPOTS
SIGNAL
J M M J S N J M M J S N J M M J S N
1924
1925
1926

Fig. 3

Washington and were continued intermittently for more than a year but without leading to any definite conclusion.

During the past year an examination has been made of the observational material on daylight disturbances between 9000 and 20,000 meters wavelength collected by this laboratory since 1918. In the earlier measurements the strength of the atmospherics was determined by the shunt across the telephone at which three crashes could be heard in ten seconds. This was subject to all the general inaccuracies of the shunted telephone method, including the effect of changing observers and possible changes in the sensitiveness of the telephones from time to time. The present

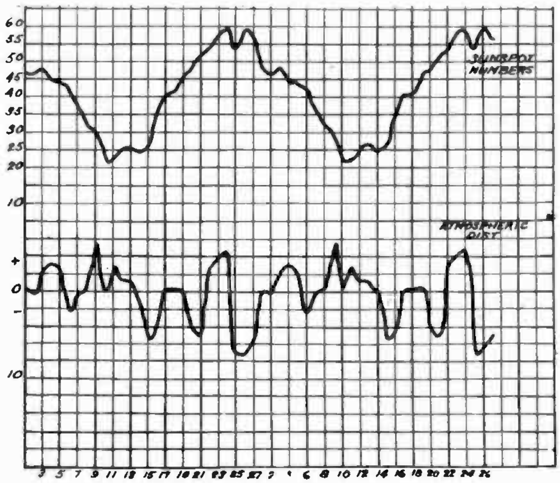

Fig. 4—27-Day Period. Atmospheric Disturbances 10:00 A.M. (f—15kc, 20,000 m.) and Sunspot Numbers, 1925.

method which was adopted in 1924 rates the strength of the disturbances in terms of the measured strength of an artificial signal which is just readable through them. The changes in methods of measurement do not permit comparisons of the earlier and later observations which are of much quantitative value. It seems certain, however, that the daylight atmospherics at 12,000 meters between 1920 and 1924 were considerably stronger than during 1918 and 1919 and during 1925 and 1926. This would indicate a general negative correlation with sunspots. This is shown in Fig. 1. The values before 1924 are dotted to indicate their comparatively low accuracy. Fig. 2 shows the deviations of the individual monthly averages from the three-year monthly averages of the 20,000-m. atmospheric disturbances and of the sunspot numbers from 1924 to 1926. The deviations are used, rather than the monthly averages themselves, in order to eliminate the large seasonal variations of the atmospherics. The increase in the sunspot numbers with the advancing eleven-year cycle is evident in the figure. The atmospheric disturbance curve, however, is rather noncommittal, but with some evidence of a negative correlation. The indistinctness of this relationship can be compared with the much more definite correlation of sunspots and signal intensity, as shown in Fig. 3, where the mean values of the daylight

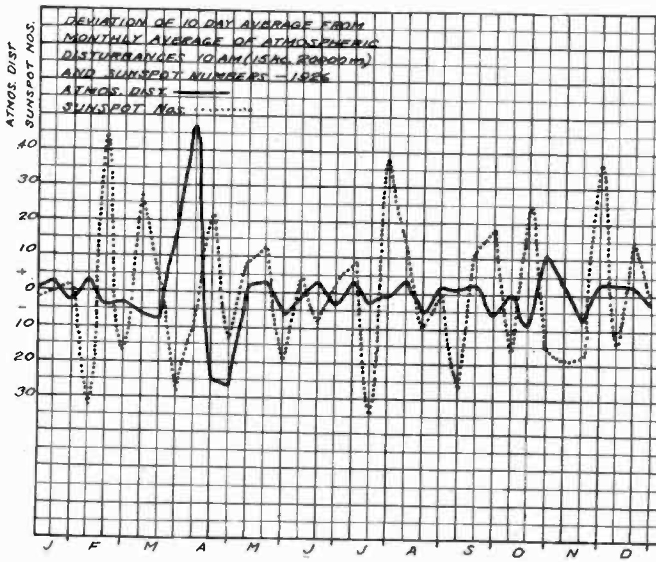

Fig. 5

signal strength of several long-wave stations are compared with the sunspot numbers by the same methods and over the same period of time.

If the atmospheric disturbances are dependent upon sunspots it would seem probable that there would be regular changes in disturbance intensity in the period of the sun's rotation. Fig. 4 shows the 27-day periodic averages of the 20,000-m. atmospheric disturbances and sunspot numbers in 1925, the points being repeated during a second 27-day period for clarity. The disturbance curve is somewhat smoothed by 3-day moving averages. It is seen that this curve, while very irregular, shows perhaps some slight evidence of being in nearly opposite phase to the sunspots.

Fig. 5 shows a comparison of 10-day averages of 20,000-m atmospheric disturbances and sunspots from January 1 to December 31, 1926. Here the prevailing correlation appears to be also on the whole negative.

For a comparison with these rather indefinite evidences of the solar influence on atmospherics, Figs. 6 and 7 show their much more definite connection with terrestrial phenomena. Fig. 6 represents the quite close relationship between 20,000 m. atmospherics

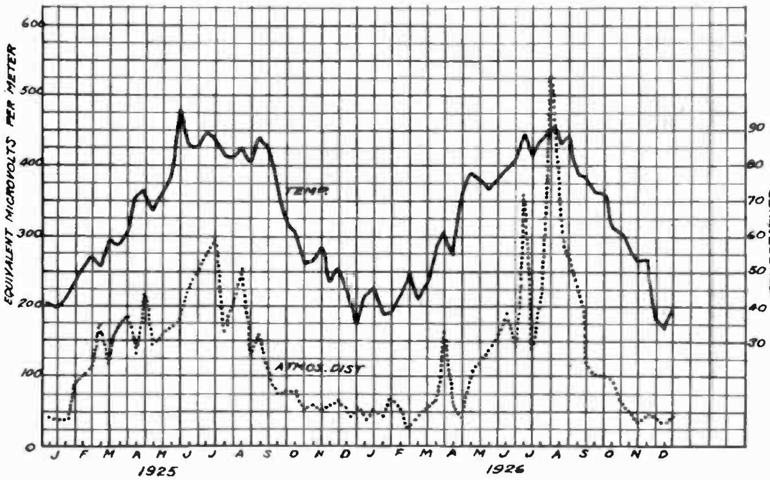

Fig. 6—Temperature and Atmospheric Disturbances—3:00 P.M. Ten Day Averages.

and local temperature averaged in 10-day periods. Here the well-known parallel variations with seasonal temperature are seen, and in addition there is a remarkable correspondence even in the small peaks and troughs of the two curves. Fig. 7 represents the relationship of atmospherics and the number of thunderstorms recorded in a region within approximately two hundred miles of Washington. Here again, as in the case of the temperature, we find a close relationship. The connections shown in Figs. 6 and 7 evidently have to do with atmospherics of comparatively local origin. Many of the disturbances are, of course, known to come from great distances, but these two figures show how prominent a part relatively local atmospherics play in the difficulties of radio reception in Washington.

In conclusion, while there seems to be some evidence of solar influences on long-wave daylight atmospheric disturbances, at present, the proof seems insufficient to establish this with certainty.

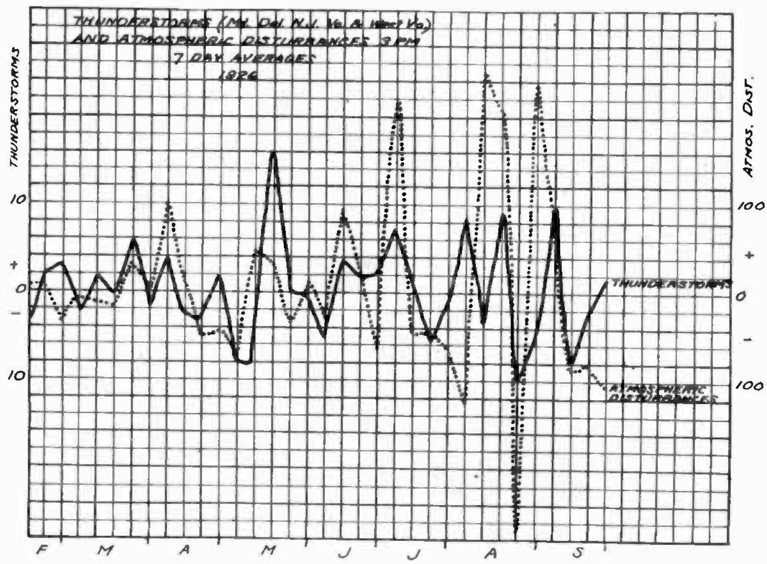

Fig. 7

It may be that the influence of solar activity on the weather and that of the weather on the atmospherics may be the indirect path by which the connection must be traced.

TWO CONTRASTING EXAMPLES WHEREIN RADIO RECEPTION WAS AFFECTED BY A METEOROLOGICAL CONDITION*

By

LIEUTENANT E. H. KINCAID, U.S.N.

(Hydrographic Office, Navy Department)

The writer has had opportunity at sea to study static with relation to the atmosphere since the spring of 1924 on board the U.S.S. *Kittery*. During 1926, these observations were made with the assistance of the radio compass. The research originally started on board the U.S.S. *Kittery* is now being continued by the Hydrographic Office, Navy Department, in collaboration with the Bureau of Engineering, Naval Communications, and the Bureau of Aeronautics.

The purpose of this article is primarily to show that static has sufficiently definite relationship to the distribution of the atmosphere as plotted on the daily weather map to enable one by proper observations to make use of static in weather forecasting, and to make use of our present knowledge of atmospheric distribution and movement in static forecasting.

This problem must be considered from two different viewpoints.

The first is by making use of instantaneous static intensities without reference to any directional properties that static may have. This might be called plotting the Highs and Lows of static such as we now plot Highs and Lows of barometric pressure.

The first experiment conducted by the U.S.S. *Kittery* for the Navy Department before the introduction of the direction finder was on this principle.

Considering that a definite relationship is established between atmospheric structure or changing structure and static, facts ascertainable concerning static from one or more points will be of value in forecasting weather and our knowledge concerning development and movement of atmospheric conditions will assist in making static forecasts.

Received by the Editor, June 8, 1927.
* Presented before the American Section, International Union of Scientific Radio Telegraphy, April 21, 1927.

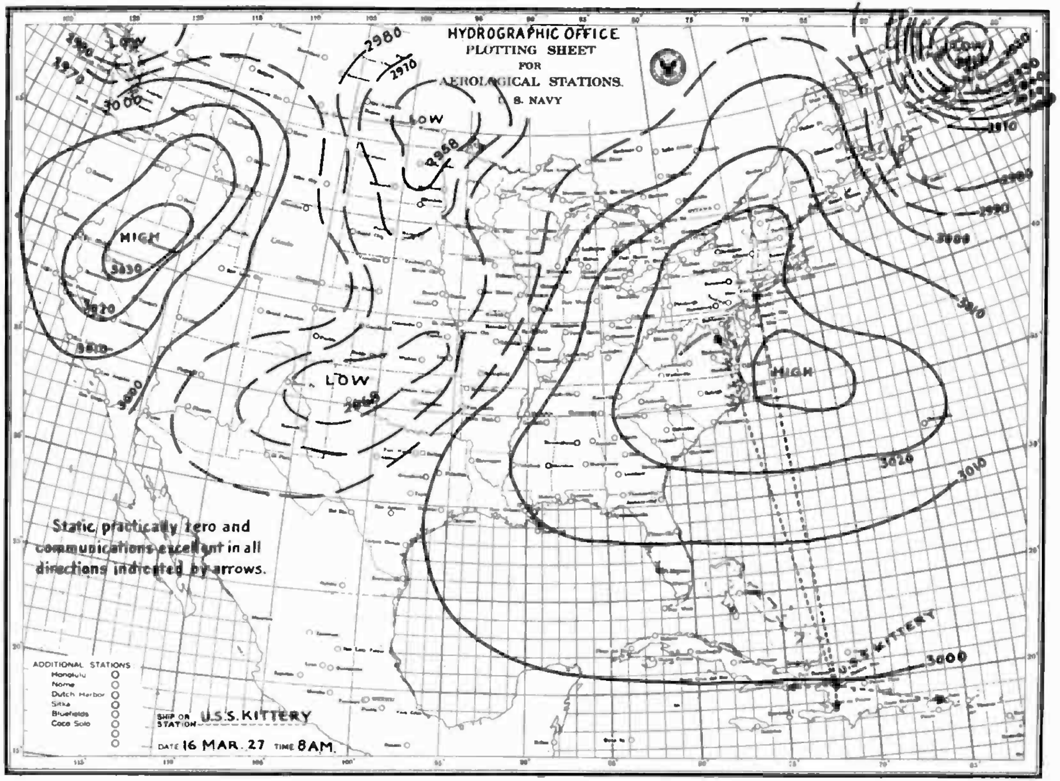
HYDROGRAPHIC OFFICE
PLOTTING SHEET
FOR
AEROLOGICAL STATIONS.
U. S. NAVY
HIGH
LOW
HIGH
LOW
LOW
LOW
3030
3020
3010
3000
2980
2970
2958
2990
3010
3020
3000
Static practically zero and communications excellent in all directions indicated by arrows.
ADDITIONAL STATIONS
Honolulu
Nome
Dutch Harbor
Sitka
Bluefields
Coco Solo
SHIP OR STATION U.S.S. KITTERY
DATE 16 MAR. 27 TIME 8AM.
U.S.S. KITTERY

Fig. 1

Add to this knowledge what directional properties static is found to have and we begin to realize the possibility of the value of a static observation to a condition remote from the station making the observation. It is this latter feature that will prove of greatest advantage to the mariner.

Two examples are given herewith of well-known meteorological conditions with contrasting types of pressure distribution. One is a well-formed homogeneous High which covers the West Indies, the South Atlantic and East Gulf States, and the ocean area adjacent thereto.

Fig. 1 illustrates the static-free and excellent communication conditions attending this High. The ship at the time off Cape Haytien, Haiti, on 16 March 1927, with a two-kilowatt set had no difficulty in communicating with Port au Prince, Haiti, Guantanamo, Cuba, San Juan, Porto Rico, Arlington, and New York.

Fig. 2, the other example, is of the same geographical area but with a hurricane, the most intense type of Low (save tornadoes) occupying a part of the same area. The Low in this case is the historical Miami hurricane shortly after it had passed over and devastated Turks Island. The position of the observer was the same during the observance of both states of weather and attendant radio reception conditions, that is, off Cape Haytien, Haiti, in this case on the evening of 16 September 1926.

In the former, the High, static was practically zero and reception excellent in all directions over long ranges within the High.

In the latter, the Low or Miami Hurricane, reception was impossible although attempts were made to communicate with all stations indicated by arrows in Fig. 2, namely, Arlington, San Juan, Guantanamo, Port au Prince, and even Cape Haytien, Haiti, which was only 40 miles distant.

Our steering gear broke here as we were entering Tortuga Channel to obtain a better lee, and had an SOS been necessary, it would have been drowned out by the intensity of the static. Fortunately, the U.S.S. *Kittery* is a twin screw ship, and we used our engines until the steering gear was repaired.

Here we deal not with theory but with facts, namely, (1) that on one occasion static was terrific and the observer was within the 29.60 isobar, southeast quadrant of a hurricane, and (2) on the other occasion the observer was within a homogeneous High and static was practically nil.

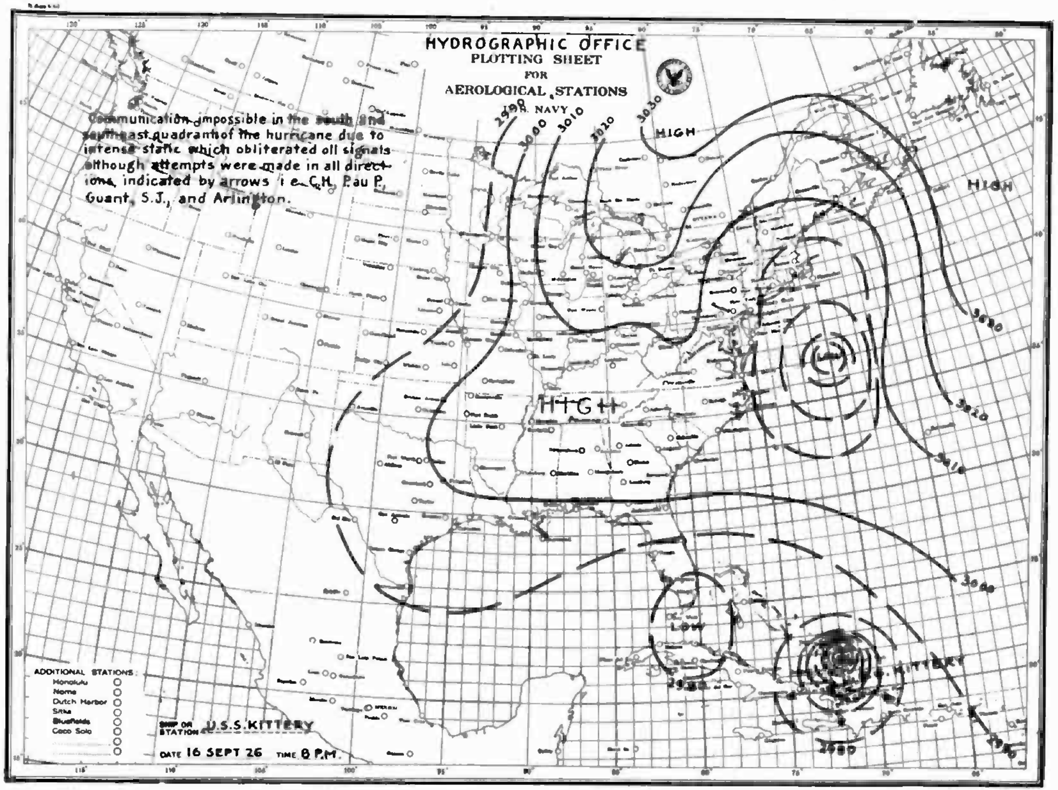
HYDROGRAPHIC OFFICE
PLOTTING SHEET
FOR
AEROLOGICAL STATIONS
U.S. NAVY
Communication impossible in the south and southeast quadrant of the hurricane due to intense static which obliterated all signals although attempts were made in all directions, indicated by arrows i.e. C.H., Pau P., Guant., S.J., and Arlington.
HIGH
HIGH
HIGH
LOW
2990
3000
3010
3020
3030
U.S.S. KITTERY
ADDITIONAL STATIONS
Honolulu
Nome
Dutch Harbor
Sitka
Bluefields
Coco Solo
SHIP OR STATION U.S.S. KITTERY
DATE 16 SEPT 26 TIME 8 P.M.

Fig. 2

The writer wishes to ask what this and similar phenomena would seem to indicate. To the observer in this case the same relative situations have recurred so often that he is of the opinion that Highs are relatively static free and Lows are attended with static somewhat proportional to the intensity of the disturbance. This seems to hold good from troughs of Low pressure to hurricanes and from poorly defined Highs with mild static to great homogeneous Highs with practically no static.

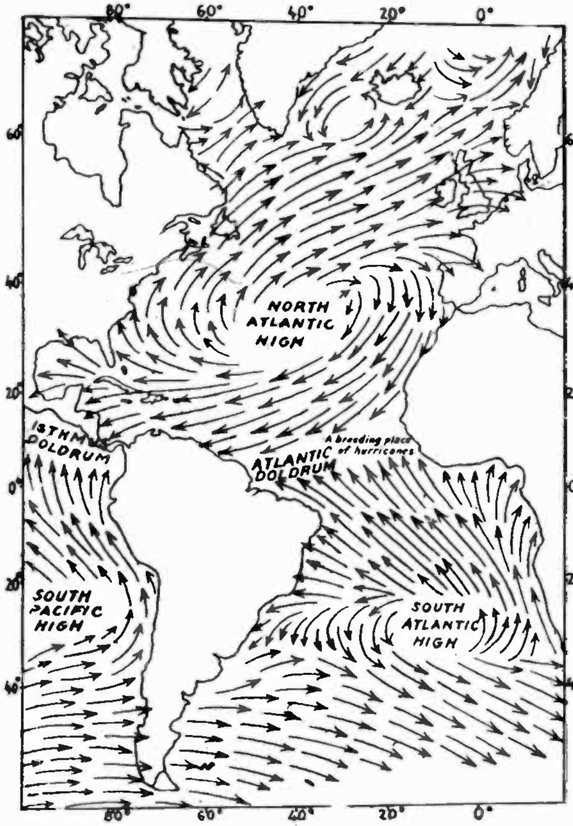

Fig. 3—Breeding Place of Hurricanes—Doldrums. (After Bartholomew's Physical Atlas, Vol. III, Plate 14.)

This High had traveled across the United States from the Pacific States where it was central on 11 March. We have every reason to believe that the same relative good reception condition had identical motion of translation.

The rate of the motion of translation of Highs is shown in many publications of the U. S. Weather Bureau and authors of meteorological works. (See Fig. 14.)

With the same accuracy as Highs are now used in weather forecasting they can be used in forecasting the negative information concerning static conditions.

The Low, or Miami Hurricane, had traveled at the rate of about 300 miles per day from the doldrums well out to the eastward of the Lesser Antilles, possibly near the Cape Verde Islands. It is a certainty that this area of heavy static and impossible communication conditions had traveled at the same relative position to the hurricane and at the same rate of 300 miles per day. (See Fig. 4.)

Considering that these things are true and that Highs and Lows and our knowledge concerning their development, disintegration, and motion of translation is to be the basis for our static forecasting, we need next to study the structure of Highs and Lows with a view to locating that part of each which may under the most general conditions be expected to give the greater amount of static. We also want to know where within the High and Low to expect the minimum amount of static for that particular structure.

In the Miami hurricane, static was stronger in the southeast quadrant than in the west and southwest quadrants. In general, the eastern half of Lows will be more heavy in static than the western; the southeast, in general, than the northeast; and the southwest, than the northwest.

On 21 March when the High mentioned above had moved to the eastward until the *Kittery's* position was in the southwest quadrant, static increased steadily.

In Highs it has been my observation that the center has the mildest static, the southeast quadrant less than the southwest, the northeast less than the northwest. Especially is this true near the edge of the structure.

Highs of different origin and hence different structure will have different static conditions associated with them. A Pacific High, deep but of limited area, will have a different static association from an Alberta High which is shallow but of great magnitude. And similarly Lows of different origin will have correspondingly different static attendant thereto.

The above facts can be reconciled with results obtained by many who are studying static with the view of correlating it with the atmosphere.

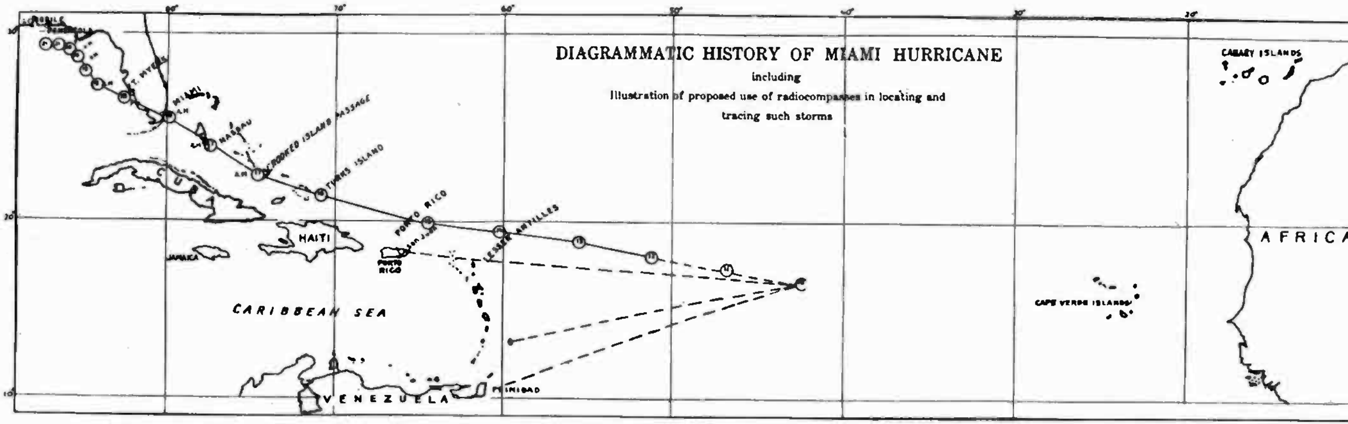

Fig. 4—Extending Known Path of Miami Hurricane Through Doldrums to Easternmost Breeding Place of Hurricanes. Known Part of Path Shown by Solid Line.

A few observations of others who have studied this subject abroad may be added here:

Abstracts of Papers on the Meteorological Relations of Atmospherics

In June, 1923, the Council received a letter from Mr. R. L. Latcham, of the cable steamer *John W. Mackay*, Nova Scotia, calling attention to the possibility of using, for the purpose of weather forecasting, observations of the character of those naturally occurring electro-magnetic waves, called atmospherics, which are so familiar to all wireless listeners. The Council appointed a small committee to consider whether observations on atmospherics might be of service in forecasting. As a preliminary to the work of the committee, the writer undertook to prepare the bibliography of the meteorological relations of atmospherics which is now reproduced here.

The correlation between the occurrence of actual thunder or lightning and the radiation of atmospherics is so well-known that many references to it have been omitted, but it is believed that no other well-authenticated data have been overlooked.

It will be seen that very acute divergences of opinion exist as to possible relations between the intensity of atmospherics on the one hand and most of the phenomena definitely recognized as "meteorological" on the other. There is an overwhelming consensus in favor of the obvious correlation with thunder, moderate agreement on the correlation with convective processes in the absence of reported thunder, but beyond this point, the evidence is mutually contradictory. Reasons for this are not difficult to assign. It is established beyond doubt that the range of reception of atmospherics may reach one or two thousand miles, it is most probable that the range frequently, if not usually, attains the length of the earth's semi-circumference. Comparisons between received atmospherics and local weather will therefore, in part, be a comparison of the weather of a parish with the electrical phenomena of a hemisphere. Moreover it is still impossible to find a scale and a classification for the intensity and character of atmospherics which shall be generally acceptable, unambiguous, and capable of assessment by the average observer. The Beaufort of atmospherics is not yet.

Nevertheless, the evidence that the atmospheric was well, if rashly, named is accumulating rapidly, and the summaries of the most recent work show that the location of "cold fronts" by radiotelegraphic observations on atmospherics is an established possibility. R.A.W.W.

After describing typical X effects from lightning, remarks that X's are more frequent in summer and autumn than in winter and spring, near high mountains than in open sea, in south than in north winds (in the Mediterranean), in the front of a cyclonic disturbance than in the rear, with falling barometer than with rising barometer.

Notes case of a heavy winter gale, without observed lightning, which was preceded by X disturbance.—Jackson, H. B.—London, Proc. R. Soc., 70 (A), 1902, p. 266.

X's in Mediterranean are worst when pressure is low, temperature high, and humidity low. The sirocco forms an exception to this rule, as it always brings atmospherics.—Crawley, C. G.—London, Elect., 69, Jan. 31, 1913.

Describes observations showing that every observed lightning flash produces an X, multiple flashes producing multiple X's, and discusses the adequacy of the known thunderstorm distribution to account for all X disturbance. The author proposes direction-finding for the location of X sources.—ERSKINE-MURRAY, J.—London, Elect., 67, 1911, p. 219.

Describes the recording of thunderstorms up to 500 km. distance by crystal detector and galvanometer.—FLAJOLET, .—Paris, C.-R. Acad. Sci., 154, 1912, p. 729.

On the basis of one year's observations at Anche (Indre et Loire) the relations between X's and weather are thus enunciated (the original French descriptions being retained to avoid ambiguity by loss of onomatopoeia).

(1) Violent "craquements" indicate a thunderstorm, approaching if the X's become more and more frequent, receding if they become less frequent or less strong.

(2) A slight "sifflement" is produced by a heavy hailstorm passing near the receiver.

(3) Dry, isolated, and rather weak "claquements" generally precede a fall of temperature, a spring frost.

(4) If the wind is about to turn, the X's are of short wavelength, and seem to come in strings.

(5) Numerous "crepitements," accompanied by fairly regular strong and "fusant" "craquements," precede great barometric depressions and foretell gales.—FRANCK-DUROQUIER.—Nature, Paris, 41 (1), 1913, p. 218.

Finds that X's and changes of recorded potential gradient go together. Balloon observations show great increase of X's inside cloud, and a rapid decrease of X's with increasing height.—LUTZE, .—Phys. Zeit., Leipzig, 14, 1913, p. 1194.

Observations at Mt. St. Aubert, Tournai, May–September, 1912, led to the following conclusions: Absence of X's characterizes approach of fine weather; little precipitate cracklings—hail or heavy rain; distant cracklings—fine weather; numerous and prolonged cracklings—stormy weather; prolonged sound like water from a gutter—sudden change of weather; prolonged and singing sound seeming distant at first, approaching little by little till strong—violent thunderstorm or tempest.—DELVAL, —Quoted in Perret Maisonneuve's "La T.S.F. et la Loi," (1914).

An outburst of X's follows a sudden change of wind on the North Atlantic coast of the United States, especially a change from South to North. X's also accompany a rise of temperature there.—MARRIOTT, R. H.—Proc. Inst. Radio Engin., New York, 2, 1914, p. 37.

X storms coincide with convective weather, rapid fluctuations of pressure, and rapid movements of depressions.

In Malta, X's precede by several days the advent of convective weather.

In Australia, day-time rain is preceded by X's in 80 per cent of all cases.

In Ireland, X's are bad with a North-West wind on the Atlantic coasts.

In Sierra Leone, the periodic dry wind suppresses X's.—RADIO TELEGRAPHIC INVESTIGATIONS COMMITTEE OF THE BRITISH ASSOCIATION. London, Rep. Brit. Assn., 1915.

From observations in the Belgian Congo, 1915–17, the author believes that X's from lightning have an effective range not exceeding 100 or 200 km.

In general a day of thunderstorm is preceded by several days of increased X disturbance.

In general a day of thunderstorm is followed by several days of reduced X disturbance. This law is more general than the former.—GOLDSCHMIDT, R. —"La Telegraphie sans Fils au Congo Belge," (Brussels, 1920).

Low X intensity is found under rainless cloud, X's increase as cloud begins to break up or as rain begins. Diminishing convection current goes with low X intensity.

From a comparison of annual variation curves the author summarizes as follows:—X maxima go with low potential gradient, but high convection current and high numbers of ions per c.c., and conversely for X minima.

From diurnal variation curves:—X's are bad when the vapor pressure is at a maximum at the surface and increasing above, when the conductivity at ground and aloft is increasing, and the surface wind decreasing. X disturbance is at a minimum with maximum conductivity at a moderate height, with overcast sky, with maximum relative humidity, minimum temperature, and maximum air pressure.—WIEDENHOFF, S.—Jahrb. drahtl. Telegraph., Berlin, 18, 1921, p. 242.

Increased X frequency indicates an imminent thunderstorm; if the intensity of X's is great, the thunderstorm will be violent, with wind and rain, if the X intensity remains low, the thunderstorm is feeble. If the intensity augments, the storm is approaching, and vice versa.

This diagnosis is valid at great distances, before the cloud associated with the storm has appeared at the receiving station.—MARCHAND, — Rev. Gen. Sci., Paris, 32, 1921, p. 594.

Infrequent but sustained X's with an intense high metallic note are due to more or less distant cloud. Visible lightning, and hail, give this type of X.

Lacosts (q.v.) is summarized.—ROTHE, E.—Paris, C.—R., Acad., Sci., 175, 1921, p. 840.

Enunciates laws based on radiogoniometric observations at Strasbourg.

(1) If a distinct well-developed depression exists, with closed concentric isobars, the maximum X disturbance proceeds from the south or south-east of the depression, the displacement in direction and variation of intensity allow of following the course of the depression.

(2) If the depression has a distant center and less curvature, the X maximum is still south or south-east of the periphery, but is less sharply marked.

(3) Secondary depressions, with "barometric pockets" and cols, correspond to storm fronts, the direction of X maximum is difficult to find, and X's are violent from all azimuths.

(4) A near thunderstorm gives violent X's from its azimuth.

Many X's received in clear weather are comparable in intensity to those of observed lightning. The author concludes that X's are due to more or less distant storm phenomena, and are often produced in overcast regions.

The last few days' work in the period in question indicates that fog facilitates X transmission.—LACOSTE, J.—Paris, C.—R. Acad. Sci., 175, 1921, p. 843.

X's come from definite azimuths when storm clouds are distant, but are observed on all azimuths when the storm is very near.

Storm clouds produce X's which gradually cease as soon as uniform rain starts, but X's persist to some extent when rain is violent.

Strato-cumulus most often furnish well-defined and oriented rumbling X's.

Re-summarizes Lacoste, Q V.—ROTHE, E.—Ann. Phys., Paris, 17, 1921, p. 385.

Describes further work at Strasbourg in summer of 1922, confirming previous conclusions, and demonstrating possibility of forecasting new depressions. Remarks on the special value of the radiogoniometer in thunderstorm forecasting.

Some thunderstorms give X's which are numerous only on short wave observations.—LACOSTE, J.—Paris, C. R. Acad. Sci., 176, 1922, p. 707.

Preliminary results of directional observations on atmospherics during 1916–18, by stations on British coasts, show that on an average five apparent sources of atmospherics per week were located. Of those checked against meteorological data, 15 per cent agreed with reported thunderstorms, 10 per cent with squall phenomena, 69 per cent with rainfall within the 24 hours containing the time of observation, without reported thunderstorms or squalls. Thus 94 per cent of the apparent sources were associated with rainfall. Thirty-five per cent of the cases examined fell on the forward edge of a rain area.—WATSON WATT, R. A.—Nature, London, 1922, p. 680.

Gives results of observations at Heidelberg, September 1919–August 1921, on 2,000 and 12,500 metre wavelengths. In the warm half-year X's developed on the appearance of a new depression over North-West Europe, disappeared on its departure or filling up.—WOLF, F.—Jahrb. drahtl. Telegraph., Berlin 19, 1922, p. 289.

Observations in the plains of Upper Rhineland, 1915–17, on 600 to 2,000 meter wavelengths, led to a classification of X's in ten groups.

(1) Prevailing weather type, a whistling sound decreasing in strength, ending almost in a whisper.

(2) Must type, weak hissing sound.

(3) Cloud break-up type, repeated groups in the form of explosive crashes. Specially marked on break-up of alto-cumulus.

(4) Cirrus type, "trrrrtasss" (palatal r.), increasing as cirrus gathers, continuing till cirrus ceases to increase.

(5) Lightning type "rrrrrrssss" (palatal r.), a more rapid "r" succession than in (4).

(6) Front type (squally wind), creak like a revolving clapper.

(7) Cumulus-development type, short single sharp cracks.

(8) Thunderstorm-cumulus type, sharp cracks of different strength, coming in groups.

(9) Sunrise type, violent rattling and scratching of longer duration, not in group form.

(10) Sunset type, superposition of (3), (9) and other types, partly due to surface cooling and condensation, partly to cloud break-up.

Every stage in the development of a thunderstorm released a definite type of disturbance. Groups 4 and 9 are superposed in thunderstorms.

The lightning type was observed at night with perfectly clear sky.

The increase in disturbance numbers started several hours before the onset of the thunderstorm, though there were exceptions to this rule.

In spite of unmistakable signs of thunderstorm the number of disturbances remained normal until a sudden release occurred.

Strong disturbances were found to come from strata of misty haze and also from forests with their well-known summer cloud formation.

Direction-finding differentiated between sharply directed X and those showing little directivity. Localized thunderstorms and squalls could be located in azimuth.—STOYE, K.—Jahrb. drahtl. Telegraph., Berlin, 20, 1922, p. 303.

Summarizes work on X's under the Meteorological Office and the Radio Research Board, gives examples of the location of thunderstorms up to 2,400 km. distant, by direction-finding on X's, and discusses the relations of X's, rainfall, and lightning.—WATSON WATT, R. A.—London, Wireless World and Radio Rev., 12, 1923, p. 601.

Atmospherics are the phenomenon that best gives evidence of the passing of meteorological disturbances in tropical regions; the other meteorological variables only indicate that passing in a much less regular way; moreover, they only give evidence of the meteorological disturbance when it has reached the observing station, while atmospherics announce it some hours in advance. —BUREAU, R., and others.—C.R. Acad. Sci., 178, 1924, p. 556; 1623; 179, 1924, p. 394; 180, 1925, p. 529; 1122; Onde, Elec., 4, 1925, p. 31; 58.

Observations at Lausanne 1919 to 1922, at Zurich 1924.

Preliminary conclusions are stated thus:

(1) Intensity frequency nature and direction of X's vary with altitude.

(2) This variation is closely connected with variations of vertical temperature gradient. Cooling augments, heating diminishes the phenomenon.

(3) Lower layers are much more disturbed than higher.

(4) Apart from X's of proved distant origin, range of X's originating in the lower layers does not seem to exceed 250 K., and remains almost always under 150 K. in mountainous regions.—LUGEON, J.—Paris, C.R. Acad. Sci., 180, 1925, p. 594.

Shows correlation between apparent sources of atmospherics and their meteorological environment. Of 490 cases examined, 25 per cent fell within 250 K. of reported thunder, a further 28 per cent were associated with more distant thunderstorms or with squall phenomena, 21 per cent more with rain, 13 per cent uncorrelated.

Reports the tracking of a cold front for 2,700 k. by automatic recorders of X's.—WATSON WATT, R. A.—London, Proc. Phys. Soc., 37, 1925.

Most of them seem to have correlated static with a local condition. I am trying to show how those local conditions are carried along with the general drift of the atmosphere and how static from them can be used in weather forecasting.

I have listed the above facts in this particular manner in order to show how much can be forecast concerning static once its relationship to High and Low structure is well established. From our knowledge of the development and motion of translation of Highs and Lows we have the basis of a static forecast which will be enhanced by an instrument which will make use of the directional properties of static.

Fig. 5 shows the Miami hurricane as it was passing over the Florida Peninsula.

Tracking the Miami Hurricane

Here it will be seen that from Guantanamo, where the U.S.S. *Kittery* was then moored, the heaviest static was in the general direction of the southeast quadrant. The center of the storm was 600 miles distant. (See Fig. 5.)

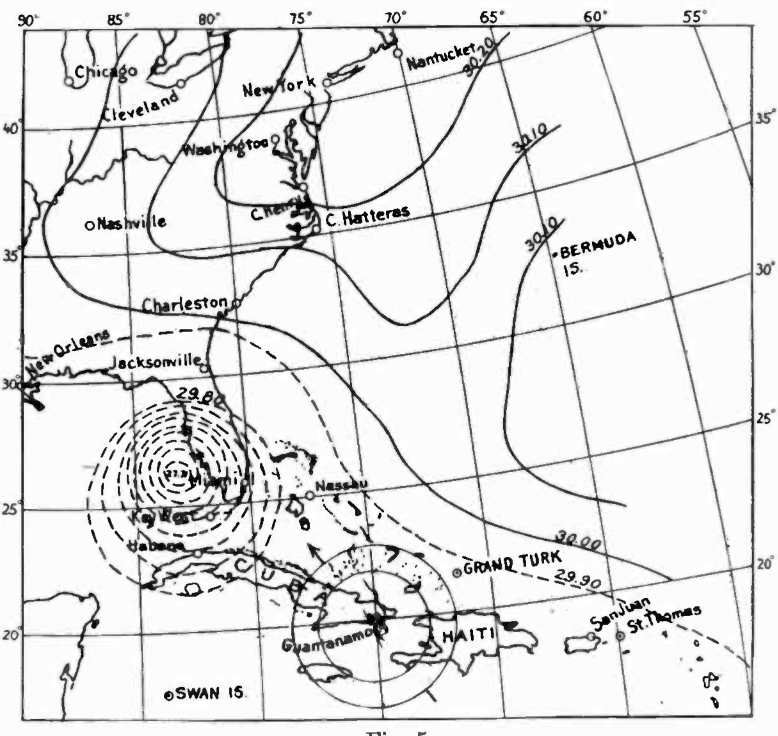

Fig. 5

Fig. 4 shows the location of the centers of the Miami hurricane from the time it was first observed to the eastward of the Lesser Antilles to the time it filled up and dissipated over Mobile, Alabama. Did not this static belt drift along with the hurricane? How far will a direction finder be able to reach out with sufficient precision as to make its use practical in habitually tracking such storms? The dotted lines show where the system may enable us to reach out in the region to the eastward of the

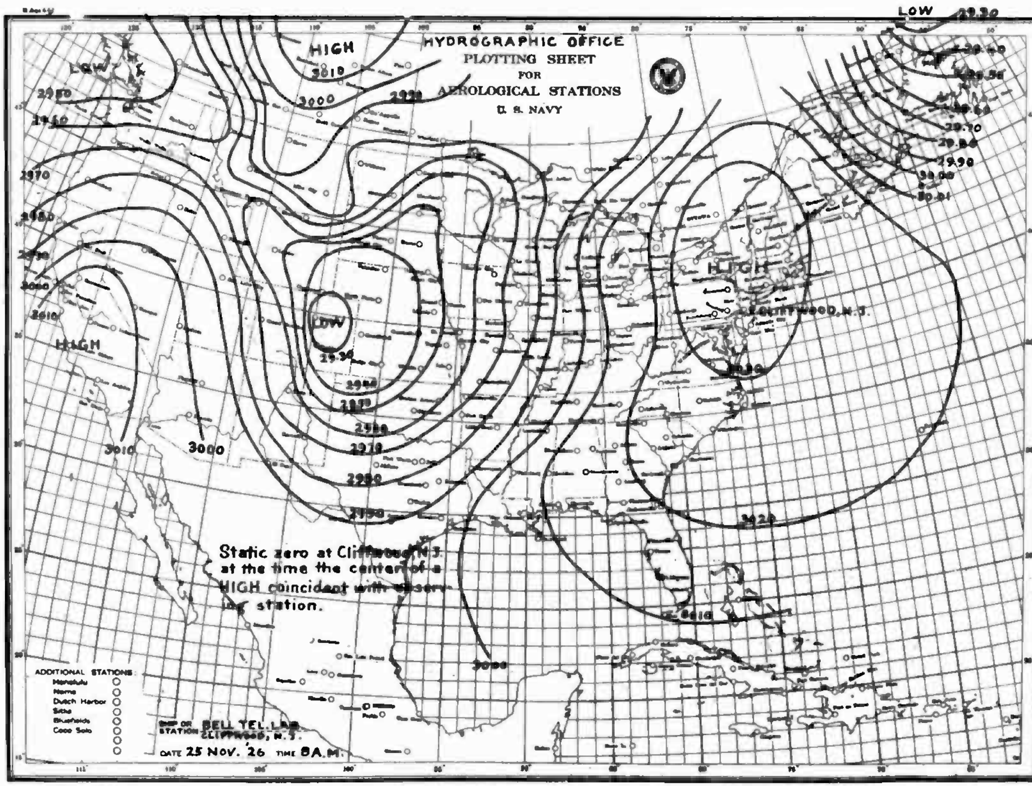
HYDROGRAPHIC OFFICE
PLOTTING SHEET
FOR
AEROLOGICAL STATIONS
U. S. NAVY
HIGH
LOW
HIGH
LOW
HIGH
LOW
Static zero at Cliffwood, N.J. at the time the center of a HIGH coincident with observing station.
ADDITIONAL STATIONS
Honolulu
Nome
Dutch Harbor
Sitka
Bluefields
Coco Solo
SHIP OR STATION BELL TEL. LAB. CLIFFWOOD, N.J.
DATE 25 NOV. '26 TIME 8 A.M.

Fig. 6

Lesser Antilles where barometer readings are scarce and triangulate such a static center in hurricane season, from St. Thomas, Barbados, and Trinidad.

The Doldrums' Breeding Places of Hurricanes

Fig. 3 shows the ideal atmospheric distribution for summer, from which the hurricane belt and the doldrums may be studied. In addition to those hurricanes that form to the eastward of the Lesser Antilles, we see the breeding place for the early spring and late fall type that form around the Isthmus of Panama, between the North Atlantic or States High and the South Pacific High. The selection of compass stations here as elsewhere will depend upon the proved range of accuracy of the radio compass for this kind of work.

Anyone working a field as new and undeveloped as this naturally finds comfort in another independent source wherein his conclusions have been verified. Mr. Friis of the Bell Telephone Research Laboratory has taken observations with an instrument developed at that laboratory over a period extending from last August up to the present date. They very generously coöperated with the Hydrographic Office in this work and I show you here the results of a part of their observations which substantiate work previously done by me.

Fig. 6 shows the High central at Cliffwood, New Jersey, November 20, 1926. Static was zero during the passage of this homogeneous High.

Following its passage, the Low shown in Fig. 7 in its motion of translation to the eastward passed over the same station. Static rose in intensity from 1 to over 400 microvolts per meter during its passage.

The direction shifted consistently from west as shown to north of east during the passage.

The graph of direction and intensity of static shown in Fig. 9 was received by their machine.

Some idea of the effect of this static intensity on the received signal is gained when the reader realizes that the Bell Telephone System try to maintain for trans-Atlantic work a received signal strength for code of five microvolts per meter and for telephony of 15 to 20 microvolts per meter.

The Hydrographic Office is pleased to see their desire of a year ago so quickly fulfilled by commercial enterprise. We said then that an instrument that would record both direction and intensity

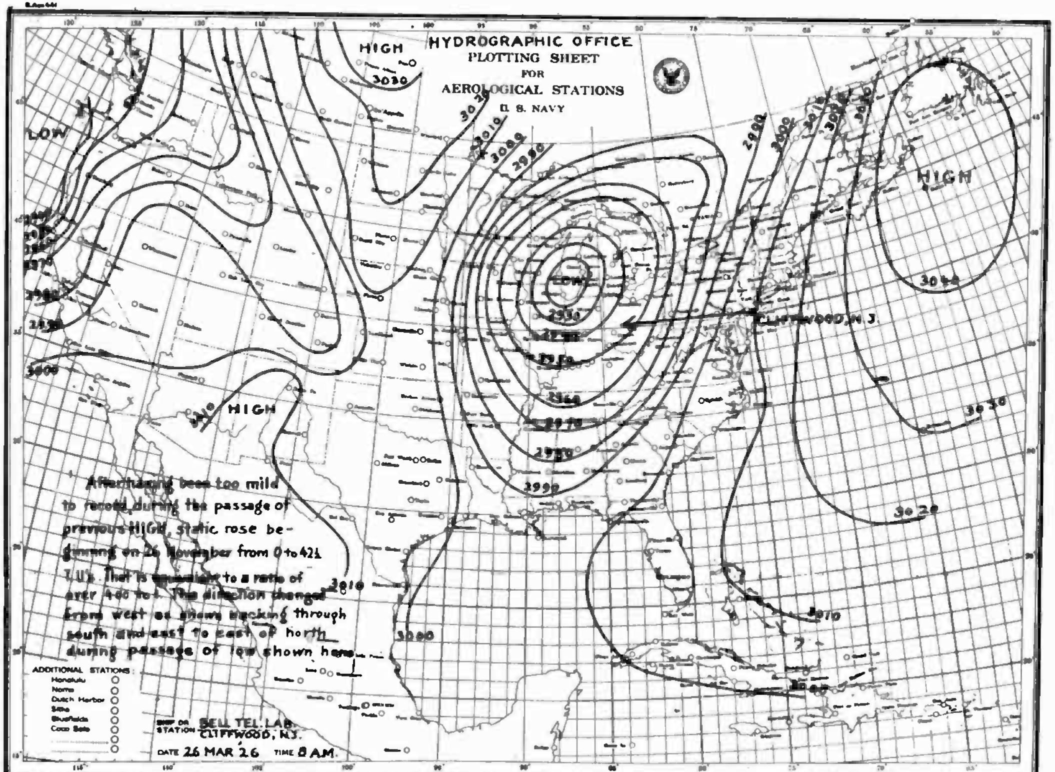
HYDROGRAPHIC OFFICE
PLOTTING SHEET
FOR
AEROLOGICAL STATIONS
U. S. NAVY
HIGH
HIGH
HIGH
LOW
LOW
CLIFFWOOD, N.J.
3030
3010
3000
2990
3040
3030
3020
3010
3000
After having been too mild to record during the passage of previous HIGH, static rose beginning on 26 November from 0 to 421 T.U's. That is equivalent to a ratio of over 400 to 1. The direction changed from west as shown backing through south and east to east of north during passage of low shown here.
ADDITIONAL STATIONS:
Honolulu
Nome
Dutch Harbor
Sitka
Bluefields
Coco Solo
SHIP OR STATION BELL TEL. LAB. CLIFFWOOD, N.J.
DATE 26 MAR 26 TIME 8 AM.

Fig. 7

of static would be necessary to the successful accomplishment of this work. Dr. Austin at the Bureau of Standards has also developed a fine automatic static recorder and there are still others.

The recorder we used is shown in Figs. 8 and 15. It is slightly different from the hookup we used at Bellevue Laboratories which was as follows:

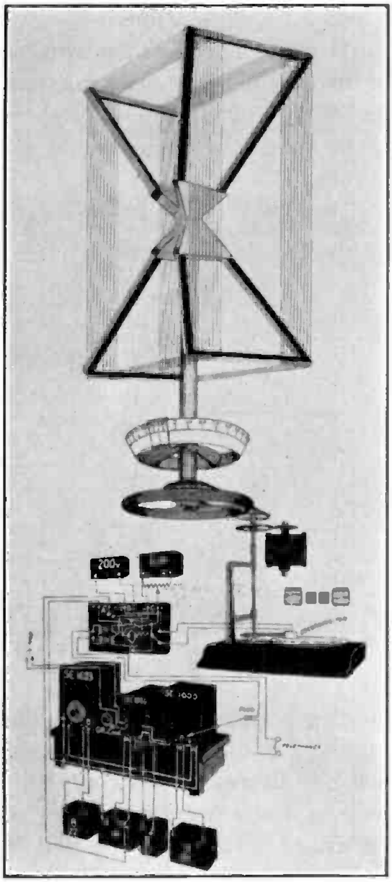

Fig. 8—Kincaid Static Recorder

The loop, an (SE-515A), was 6 ft. high, 4 ft. 3 in. wide, and consisted of 90 turns, spaced over an axial length of 4 ft. 3 in. The loop center was grounded.

The terminals were connected to an (SE-1834) amplifier and tuned by a 0.01 μ.f. variable condenser (SE-1830).

The amplifier had three radio frequency stages, a detector, and two audio frequency stages of amplification.

An additional audio frequency stage was used, the output of the latter being connected in parallel, and the negative grid bias being adjusted for zero plate current, at zero signal, by means of a potentiometer. The plate current of the two tubes actuated a pen which was shunted by a 1 μ.f. condenser.

The instrument combination described above results in depression of the pen for each static crash.

The pen records on a card, which rotates very slowly in synchronism with the compass loop, two maxima and two minima being indicated for 360 deg. of rotation (a bilateral loop operation). Some unilateral experiments were conducted at Bellevue.

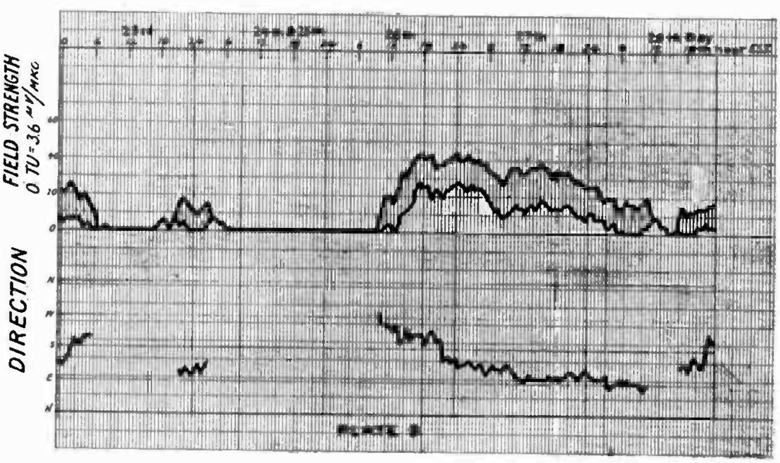

Fig. 9

The motor was so geared as to be able to make one revolution in six to ten minutes. From this it can be seen that each of the static graphs contains from three to ten complete revolutions of the compass and consumes from twenty minutes to 1½ hours.

The recorder used at Cliffwood by the Bell Telephone Laboratories is shown in the schematic diagram Fig. 10. It is an ordinary double detection set that requires altogether ten tubes, of which the last low frequency amplifier tube must be able to handle 10 watts in order to prevent overloading. The power supply may be rectified AC.

The gain control is inserted in the first intermediate frequency amplifier in order to be sure that no tubes are over-loaded. The local oscillator shown is used for amplification calibration of the set and requires no special shielding as its input voltage induced into the loop is comparatively large.

The selectivity of the set is determined by three separate units, viz., the antenna circuits, the intermediate frequency filter, and the low frequency filter, each of which has a specific use. Carson and Zobel[1] have made the following statement:

"In filters designed to select a band of frequencies of width W, the ratio of energy transmitted through the network by the signal and by random interference is inversely proportional to the band width and increases inappreciably when the number of sections is increased beyond two."

The main purpose of the filters is therefore not to define the frequency band of the set insofar as static is concerned, but to exclude continuous wave interference. It is hoped that 500 cycles

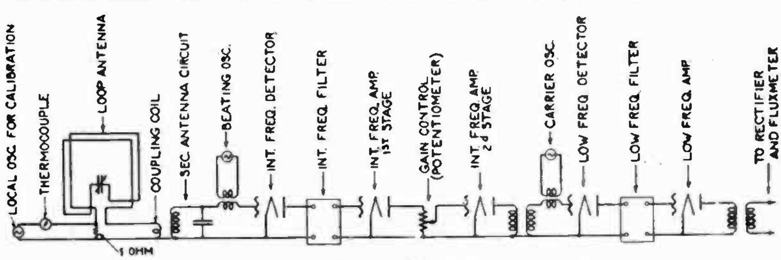

Fig. 10—Schematic Circuit Diagram of Receiving Set.

wide frequency bands[2] can be maintained free of c.w. interference for static measurements and the simplest way to obtain such a band in the receiver is to make the low frequency filter an efficient low pass filter that cuts off every frequency above 600 cycles. More than two coupled circuits are hardly required in the antenna circuits, but the intermediate frequency filter ought to have sharper cut-off points than two coupled circuits will give. The selection of filters naturally depends upon the c.w. interference and it may in some cases be possible to reduce the number of filters and thereby make the recorder cheaper. The records shown later correspond to a frequency band of 2000 cycles—between 57.5 and 59.5 kc.,—but it will probably not be long before c.w. interference makes it necessary to reduce this band width. It is desirable to have a loud speaker connected to the output of the set and occasionally listen for c.w. interference.

[1] "Transient Oscillators in Electric Wave-Filters"—John R. Carson and Otto J. Zobel, Bell System Technical Journal, Vol. II, No. 3, p. 27.

[2] Bands at 15, 30, 60, 120—kilocycles would probably be satisfactory.

The constant-output control apparatus is shown in Fig. 11. The fluxmeter is seen in the upper right corner. Full deflection corresponds to 2×10^{-4} coulomb. The needle is normally free to move except when the cam Z presses the needle down until its point touches the scale OS. The shaft carrying the cam Z and the disk N is rotated one complete turn in 15 seconds by a clock motor. The different elements are explained in the figure and the whole action may be understood by studying this carefully. However, it is probably worth while to go through a complete 15 second period and explain in detail the purpose of each part.

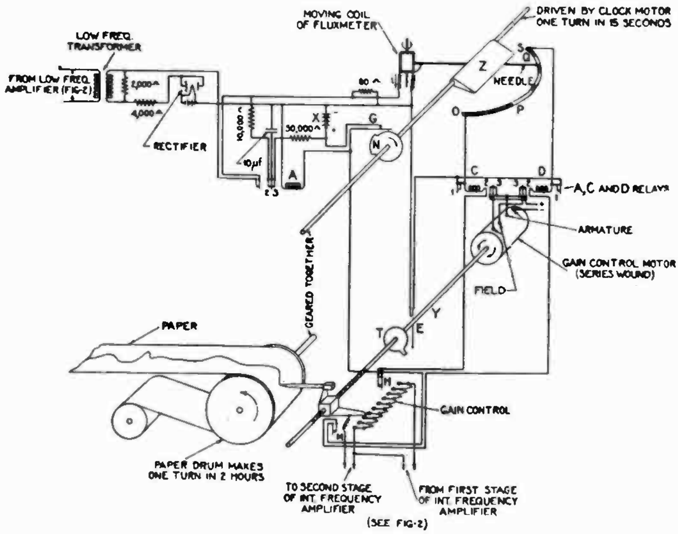

Fig. 11—Schematic Circuit of Constant-Output Control Apparatus.

Time in Seconds—0–10:

Switch G is open, therefore relay A is open and no current can pass through the windings of relays C and D. (These relays start the gain control motor, which is therefore shut off.)

Contact 1 of relay A is closed and closes the circuit consisting of the secondary winding of the low frequency output transformer, the rectifier for the static currents and the fluxmeter. The 2000- and 4000-ohm resistances in this circuit insure distortionless input voltage to the rectifier. The fluxmeter is damped by an 80-ohm shunt. The needle, which was initially at zero, will therefore move, its deflection being proportional to idt.

Time in Seconds—10–14:

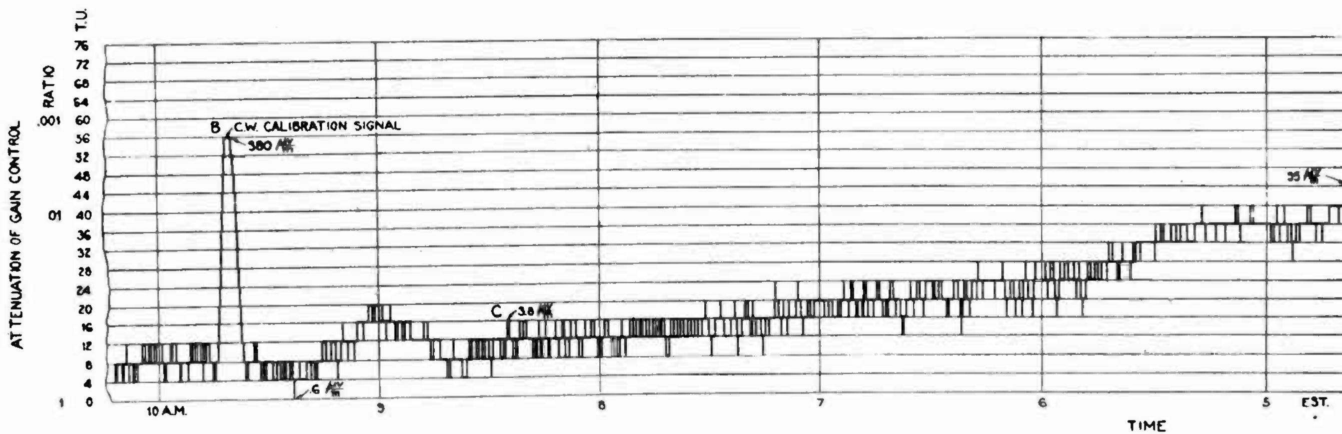

Fig. 12—Static Record, Morning of October 30, 1925, Cliffwood, N.J., U.S.A.

Switch G is closed by the cam on the revolving disk N and locks relay A.

Contact 1 of relay A is opened and opens the rectifier fluxmeter circuit, thereby bringing the fluxmeter needle to s stop.

Contact 3 of relay A is closed and makes the battery X charge the 10-μ.f. condenser through the 50,000-ohm resistance.

Time in Seconds—11–14:

The cam Z presses the needle point down on the scale OS. Now, one of three things will happen.

1. Static has decreased since the last period, so that the needle point will make contact with the metal strip OP and close the following circuit: Battery X, needle of fluxmeter, winding of relay C, switch H and switch G to battery X. Relay C is therefore closed and its closed contact 2, together with contact 3 of the open relay D will start the gain control motor. After approximately half a turn of the gain control or motor shaft Y the needle point is

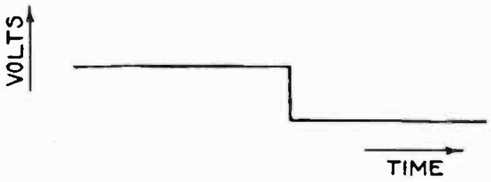

Fig. 13—Shape of Impulse Voltage.

lifted from OP by the rotation of the cam Z, but relay C stays closed due to the fact that it is self-locking through its contact 1, so that the shaft Y continues turning until the switch E is opened by the disk T. This opens the self-locking circuit of relay C. Relay C therefore opens and the gain control motor stops after the shaft Y has made exactly one complete turn and increased the gain of the set one step (4 Transmission Units or 1.58 times). Notice that the opening of the needle point contact does not break any current, due to the use of self-locking relays. This preserves the needle point contact.

2. Static has not changed since the last period. The needle point will now touch the insulating strip PQ and nothing else will happen, i.e., the gain of the set remains unchanged.

3. Static has increased since the last period so that the needle point now will make contact with the metal strip QS and close relay D and as in case 1 the motor will start and turn the shaft Y one turn, but this time in the opposite direction, i.e., the gain of the set is decreased one step.

Time in Seconds—14:

Switch G is opened again by the revolving disk N and opens relay A. Contact 2 of relay A is closed and will discharge the 10-μf. condenser through the fluxmeter, thereby bringing the needle back to zero. (Notice that the time constant of this discharge circuit is $10{,}000 \times 10 \times 10^{6} = 1\text{-}10$ seconds.)

Time in Seconds—15:

A new period has started.

The purpose of the switches M and H is to stop the motor when the gain control switch arm has reached the end of the scale.

The recorder is of such recent development that no comprehensive data are yet available.

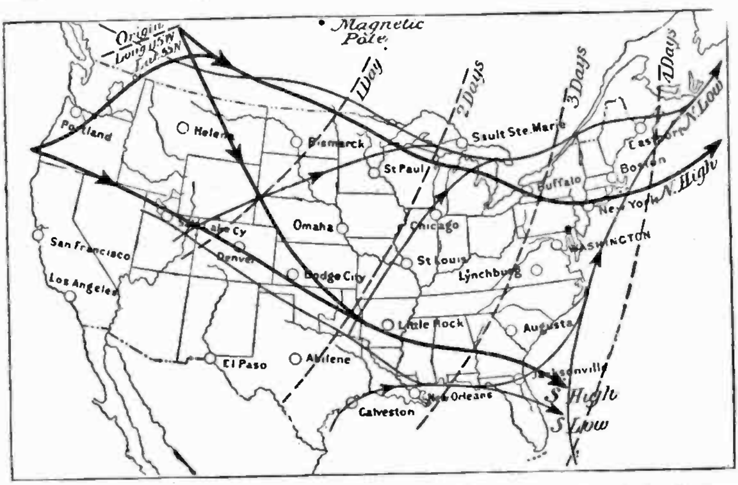

Fig. 14—The Bigelow System of Storm Tracks Across the United States.

Fig. 12 shows part of an actual record of static received on a set tuned to 57.5–59.5 kc. The ordinates represent the attenuation of the gain control of the set and it is to be remembered that the gain of the rest of the set is constant. The curve shows that the static power on the morning of October 30 changed more than 10,000 times. The point B on the curve gives the effect of inducing a local signal of strength 380 microvolts/m. in the loop.[3] The point C on the curve shows that at 8:25 A.M. the static intensity received on a 2000-cycle wide frequency band corresponded to the energy received from a c.w. signal of strength 3.8 microvolts/m.

[3] It may be worth while to have such a calibration signal introduced automatically for instance once every two hours.

It would be practical always to relate static to such a c.w. signal. Experiments are now being conducted to determine whether the energy received from static is proportional to the width of the frequency band of the receiving set, and if such is found to be the case then it is proposed to have the data relate to a 1000-cycle wide band. That static is, say, 7 microvolts per meter per kilocycle (7 microvolts/m./kc.) would then mean that the energy of the static received on a 1000-cycle wide frequency band is the same as the energy received from a c.w. signal of strength 7 microvolts/m.

Attempts have been made to calibrate the set by inducing in the loop, voltages of the shape shown in Fig. 13. Relating static to such signals would have the advantage of being independent of the band width of the set. Such signals were obtained by closing and opening a mercury switch, but one signal per second, or 10 impulses per period, would overload the set (the tubes) very much. At least 10 impulses per second would be required if the set should not be overloaded by each individual impulse, but this would be a difficult task to accomplish and it is therefore recommended that static be measured as explained above, by inducing a local c.w. signal into the loop. The fact that five static crashes in the course of 10 seconds—one period—does not overload the set while 100 impulses of the shape shown in Fig. 5 are required to prevent overloading gives us some interesting information on static. It shows that a single static crash is not a single sudden change of the field in the ether and that it can not be represented by less than 20 consecutive impulses.

The record of Fig. 12 shows that each step on the gain control potentiometer is 4 *TU* and the selection of such steps and of 15 seconds will not be discussed. To decrease the 4 *TU* step to a 1 *TU* step would decrease the speed of the set, i.e., it would take four times longer for the recorder to register a sudden change in the static level which is particularly a disadvantage when the recorder is connected to a rotating directional antenna.

On the other hand a step larger than 4 *TU* would not give the static level with sufficient accuracy. If the time periods are changed from 15 to 10 seconds, then the "speed" of the set is increased, but the set is then inoperative over a larger part of the period since it takes 5 seconds to change the gain of the set and bring the fluxmeter needle back to zero. Besides, such a decrease in time period would increase the probability of overloading and also it would make the energy received per period

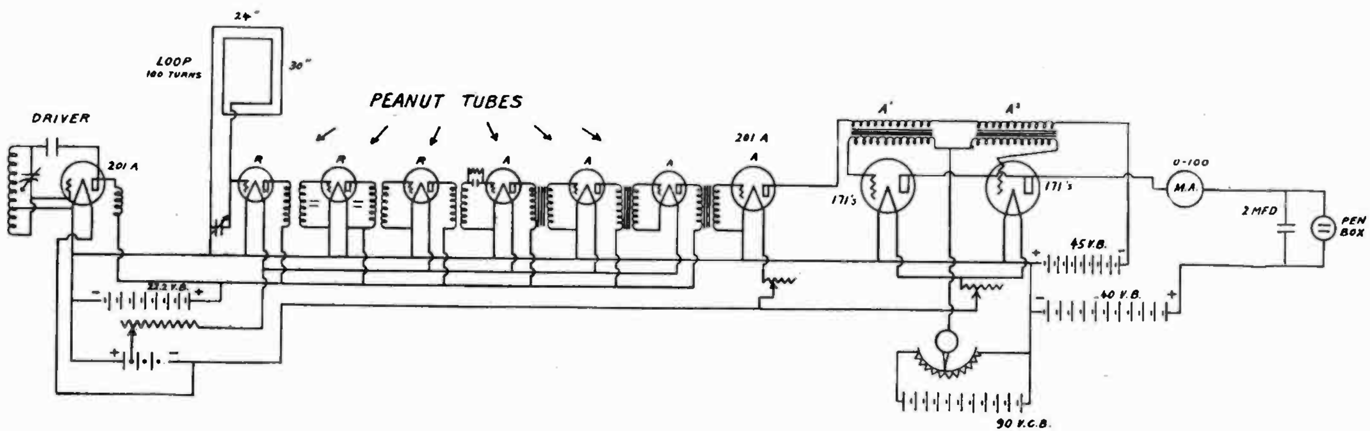

Fig. 15—Schematic Diagram of Kincaid Static Recorder. *Kittery* Installation.

vary more irregularly especially if static consisted of separate crashes.

TABLE OF CONVERSION OF TRANSMISSION UNITS TO RATIOS

TU	Ratio
0	1
6	2
12	4
20	10
40	100
60	1000

Dr. Friis in describing his static recorder says, "The reason for the small advance which has been made to date in the automatic recording of static is probably due largely to the lack of suitable apparatus. Certainly there has never been any doubt that automatic records would be very valuable. It is just as important to know the static level as it is to know the strength of a radio signal because it is the static to signal ratio that determines the intelligibility of the signal. A static recorder connected to a rotating directional antenna system would tell us where static comes from and, therefore, enable the radio engineer to determine whether it is worth while to construct a directive antenna system. Also the connection between thunderstorm areas and static would make static recording valuable to the meteorological service. There is perhaps no reason why a suitable static recorder should not make it possible in a few years to obtain a daily static forecast just as we get our weather forecast now."

I believe another year will see such static forecast as Dr. Friis mentions possible, and with such forecasts will come a more exact knowledge of the relation of storms to static. The result of this will be the identification and tracking of many storms which are difficult especially over ocean areas where barometer readings are scarce, and the definite forecasting of communication conditions.

A RADIO INTER-COMMUNICATING SYSTEM FOR RAILROAD TRAIN SERVICE

By

Henry C. Forbes

(Formerly of the Zenith Radio Corporation, Chicago)

1. Problem

In present day practice, communication between the front and rear ends of moving freight trains is carried on almost entirely by visual (arm or lantern) and whistle signals. Under certain conditions the air-brake pressure line may be used to transmit signals from rear to front of the train. Economic as well as safety considerations demand that some sort of communication be maintained between the conductor in the caboose and the engineman in the locomotive, principally in order to expedite the handling of the train.

Something of the difficulties encountered in the operation of trains of one hundred or more cars (approximately one mile) in length may be realized when it is considered that when using a visual communicating system, a heavy rain or snow storm, a heavy fog, curves in the track, hills, cuts, smoke, running "into the sun," and occasionally, diverted attention on the part of the engine crew, may partially or wholly prevent such communication. On occasions when stopping the train is imperative and the attention of the engine crew cannot be obtained by signaling from the caboose, it is possible to release the air at a valve provided for the purpose in the caboose, thereby setting the brakes at the rear end of the train and, if the train is not too long, reducing the air pressure in the locomotive so as to give warning that it is desired to pass a signal or to stop the train. On extremely long trains it is sometimes practically impossible to reduce the pressure in the locomotive sufficiently by this method to produce a definite signal. In such cases, the brakes are, of course, heavily set at the rear end of the train, and it is not uncommon to break a train in two or to pull it off the track while on a curve, in attempting to signal the locomotive in this manner.

At the instigation of Committee No. 12 (Radio and Wire Carrier Systems) of the American Railway Association, the Zenith

Received by the Editor, July 13, 1927.

Radio Corporation undertook, in January, 1926, the development of a radio inter-communication system for such freight service. In response to a questionnaire submitted to that committee, it was ascertained that it was the opinion of the interested railroad that while either a one-way or two-way radio signaling system would be a distinct improvement over the existing methods of signaling, what is really desired is a complete two-way telephonic inter-communicating system, providing, of course, that such a system can be made sufficiently strong and simple of operation to be entirely reliable. The New York Central Railroad, through the office of the General Superintendent of Telegraph and Telephone, and Committee No. 12 of the A.R.A., volunteered the use

Fig. 1—Showing Length of Train Equipped With Radio Intercommunicating System.

of its equipment and facilities for any tests or experiments which might be deemed necessary during the development of the apparatus. During the subsequent development of the apparatus, several conferences with members of a subcommittee appointed for the purpose were held in order to correlate, in so far as possible, the development of the apparatus with existing standard railroad practice.

2. Requirements of the Service

Several rather difficult problems were presented in the design of suitable equipment for this service. There is no source of electric power on a caboose, and it was not considered practicable to utilize the power from the turbine-driven headlight generator on the locomotive. Battery-operated sets were therefore necessary at each end of the train. It was necessary to provide sufficient power to produce an understandable loudspeaker signal at the opposite end of the longest train that might be encountered, while the train was running at top speed. At the same time it was desirable to limit the power used in order to limit the size of the apparatus and the drain on the batteries, and also to minimize the possibility of interference should the use of such apparatus become general.

The choice of a suitable antenna for the locomotive was a considerable problem. Modern road engines are constructed entirely of steel with an overhead clearance of about five inches at the center of the cab roof, and only about 20 inches at either side of the cab. It was desirable that the antenna used should be mounted entirely on the locomotive, so that the coaling operations and the taking of water would not be interfered with. The antenna must be constructed within the overhead clearance limits, must be sufficiently sturdy to withstand road service, and should transmit efficiently under all weather conditions, and in all directions in the horizontal plane so that the signals will not fade while making sharp curves.

The mounting of the radio apparatus itself required some attention inasmuch as it is necessary that it be installed in an extremely small space. It must be completely shielded, should withstand water and soot and exposure to heat, and must be extremely carefully cushioned against the terrific jarring and battering to which it is continually subjected in railroad service. Sturdiness and simplicity of operation are essential.

3. Development

Preliminary tests of the apparatus undergoing development were made between a fixed station at the Zenith laboratory, constructed to simulate the installation on a train, and a mobile station installed in an automobile. Several tests and experiments were also made in the Chicago yards of the New York Central Railroad to determine the characteristics of transmission from antennas installed on the road engines. The form of antenna finally selected consists of a single-turn horizontal loop mounted closely above the cab roof on the locomotive and around the cupola on the caboose. Such an antenna is nearly non-directional in the horizontal plane parallel to the ground, and the transmission may therefore take place in any direction from either end of the train.

purpose. When communication is desired, the button on the handle of the microphone is pressed, thereby actuating the relays which make the necessary switching connections for operating the transmitter. The button is released to restore the receiver to operation. The switching, including the starting of the dynamotor, takes only about one second, and very rapid two-way conversation is possible.

The functioning of the apparatus is indicated to the operator by the flashing of colored pilot lights. One light indicates that the receiver is in operation. A second flashes when the "talk" button is pressed, and indicates that the transmitter is ready for operation. A third pilot light is operated directly from the antenna current, and the flashing of this light indicates to the operator that the transmitter is functioning properly. This third light also flickers with the modulation, giving a direct indication that modulation is taking place. The meters shown in the photographs are not to be used on permanent apparatus.

A signaling system has also been provided which may be used to attract the attention of the crew at either end of the train. This signal is operated by pressing a second "signal" button which is mounted either on the microphone handle or on the set proper, and, when operated, produces a shrill note of about 800 cycles in the loudspeaker at the opposite end of the train. This frequency was selected for this purpose after some experiment, and is readily discernible in the locomotive through the noises encountered in running. This signal may also be used to pass code signals in case of failure of the telephonic system.

Special microphones were used in order to avoid the introduction of the terrific road noises into the communicating system. An aircraft type of anti-noise microphone, originally developed for war service, was found to be very satisfactory.

Extraordinary cushioning of all apparatus in both transmitter and receiver was necessary in order to protect the parts properly from the destructive vibration and shock encountered in railroad work. Combinations of heavy sponge rubber and spring suspensions were found to be generally satisfactory, although some difficulty has been experienced in sufficiently quieting the detector tube.

For the purposes of demonstration, one set was mounted on the inside of the rear bulkhead of the locomotive cab over the rear opening. Special plugs and cordage connected the set with the batteries, dynamotor, and filter, which were mounted in a shovelrack just outside of this same bulkhead. The leads to the loop antenna were run directly up through the cab roof. A loudspeaker horn was mounted just to the rear and above the head of the engineer, so that the sound was projected directly past his head. The hand microphone, with its control button was placed in a clip convenient to both the engineer and the fireman.

In the caboose the set was installed flush into the side of a locker convenient to the conductor's desk, with the batteries, dynamotor, and filter mounted on the floor of the locker. The leads to the loop antenna went out directly through the roof. The loudspeaker in this case was mounted overhead at one end of the car.

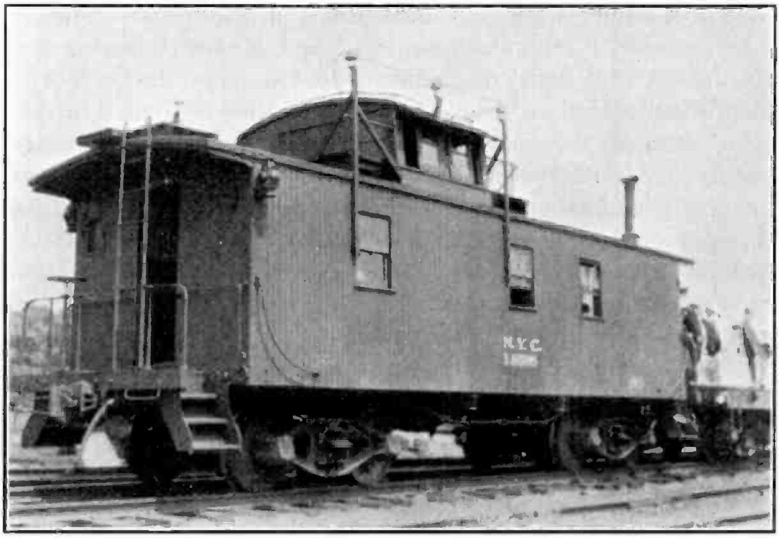

Fig. 3—Antenna on Caboose.

4. Preliminary Tests

In the first of the preliminary road tests of the apparatus on June 11, 1926, a special train of twelve cars was run over the western division of the New York Central between Elkhart, Ind. and Chicago (Englewood), a distance of about 100 miles. The apparatus operated in a manner considered very satisfactory by the several railroad men present. No difficulty was had in maintaining two-way conversation between the caboose and the locomotive when standing still or when running at top speed. The engineer was able to hear and understand everything coming from the loudspeaker behind his head without diverting his attention from the road ahead. The fireman was able to handle the apparatus and to carry on extensive conversations with the officials in the caboose. All train orders were given by means of the radio installation, and those present, including the train crew, were quite enthusiastic as to the possibilities of such radio apparatus. A severe rain and electrical storm was encountered over practically the entire run, which occupied about five hours, and aside from the sharp crashes heard in the loudspeakers, it caused no trouble whatsoever. Near Pinola, Ind., the train was stopped and the engine uncoupled from the train and run ahead under orders given entirely by radio from the caboose, in order to simulate the conditions of a broken train, and to determine if possible, the range of the apparatus. Communication was maintained with loudspeaker operation at both ends up to a distance of four miles, the locomotive then being at Hudson Lake, Ind. Lack of time prevented further tests, although the signals at that distance were still quite satisfactory, even with the locomotive in motion. The country between the engine and caboose during this test was rather hilly, and the engine passed through several cuts and around several curves without affecting the operation. During this test it was found that overhead power wires and small signal bridges had practically no effect on the operation of the system. When passing under a large steel bridge, however, communication is broken (except for weak headphone signals) while either the locomotive or caboose is actually under the bridge. The communication is not affected by the presence of the bridge between the engine and caboose after the engine has once cleared it. It was also found that there were no interfering disturbances produced on adjacent land telephone wires alongside the right-of-way, even with the caboose transmitting within 30 feet of a phone box. The passing of a train going in the same or opposite direction upon an adjacent track was found to have no effect upon the operation.

Subsequent tests in the Chicago yards have indicated that satisfactory communication may be maintained between the caboose and locomotive up to a distance of six miles with this apparatus. Beyond this distance only headphone signals are possible. Communication has actually been held at a separation of eight miles between a moving locomotive and a stationary caboose. It is expected that tunnels will completely prevent communication while either end of a train is in or near the tunnel.

5. Official Tests

An official demonstration of the apparatus before Committee No. 12 of the American Railway Association and a large party of officials of various railroads and representatives of the press was given on July 8, 1926, on a New York Central freight train operated between Chicago (Englewood) and Elkhart, Ind. There were 116 cars in the train, of which approximately sixty were loaded. A coach and a business car were placed before the caboose for the accommodation of the representatives. During the run of approximately five hours the practicability of a radio communication service of this nature was clearly demonstrated. A number of orders were transmitted which saved the delays which would have otherwise occurred while a member of the train crew walked the entire length of the train. Practically all of the representatives carried on a conversation with the engine crew at some time during the run. With the exception of minor difficulties caused by the loosening of cordage connections by the severe vibration, no particular difficulty was encountered in maintaining complete and satisfactory communication between the caboose and the engine at all speeds. During the run, the train was double-headed and a pusher locomotive was used directly behind the caboose for a short distance. This apparently had no effect upon the operation of the radio system. The consensus of opinion of those present was undoubtedly that the application of radio communicating systems to railroad service was in immediate prospect.

In future designs of apparatus for this purpose, it is proposed to provide several fixed wavelength adjustments on the transmitters, any one of which may be selected at will by the manipulation of a switch. It is contemplated that instructions will be given to the train crew before the run is started as to which of these several wavelengths is to be used by that train during its run. Trains traveling in the opposite direction would be operated upon another wavelength and there would be no interference between the trains while they were passing or within range. Communication between the two trains would be readily possible at any time they were within range, however, by merely turning the master switch to the wavelength of the other train and proceeding in the usual manner. The receivers would be made with a single wavelength control adjustment which would cover all of the wavelengths in use. Inasmuch as there are a number of channels available within the band assigned to this service, there should be no difficulty with interference for some time to come.

6. Other Uses

With the application of radio communication to railroad freight service comes also the application of a similar service to passenger train operation, not only for the purpose of train handling, but also for the purpose of intercommunication between trains, and between a train and a way-station. A further application which has been given some consideration is that to large freight yards where one towerman controls all of the locomotives working in a yard perhaps five miles in length. Much time is now lost because of the lack of prompt communication between the tower and the individual locomotives.

Summary

The problem of communication between the front and rear ends of long freight trains is briefly discussed, and a two-way telephonic radio intercommunicating system developed for this service is described. The results of tests of the apparatus under working conditions are also given.

Acknowledgment

The writer wishes to acknowledge sincerely the hearty cooperation and assistance of the officials of the American Railway Association and the New York Central Railroad in the conduct of the experimental work during the development of this apparatus. Particular mention is also due H. H. Meinhard and G. Gustafson of the Engineering Department of the Zenith Radio Corporation for their part in the development.

DIGESTS OF UNITED STATES PATENTS RELATING TO RADIO TELEGRAPHY AND TELEPHONY

Issued August 30, to September 13, 1927

By

JOHN B. BRADY

(Patent Lawyer, Ouray Building, Washington, D. C.)

1,640,393—OPTICAL MEANS FOR GENERATING, AMPLIFYING, AND CONTROLLING ELECTRIC CURRENTS—WILLIAM W. COBLENTZ, of Washington, D. C. Filed Sept. 18, 1923, issued Aug. 30, 1927.

1,640,427—RADIO RECEIVING SYSTEM—C. W. RICE, of Schenectady, N. Y. Filed Nov. 21, 1922, issued Aug. 30, 1927. Assigned to General Electric Co.

1,640,462—ELECTRON DISCHARGE DEVICE—R. C. MATHES, of Wyoming, N. J. Filed Oct. 16, 1924, issued Aug. 30, 1927. Assigned to Western Electric Co., Inc.

1,640,503—ELECTRON DISCHARGE DEVICE—W. G. HOUSKEEPER, of New York, N. Y. Filed Oct. 30, 1922, issued Aug. 30, 1927. Assigned to Western Electric Co., Inc.

1,640,534—RADIO ANTENNA SYSTEM—F. CONRAD, of Pittsburgh, Pa. Filed Dec. 14, 1920, issued Aug. 30, 1927. Assigned to Westinghouse Electric & Mfg. Co.

1,640,561—VARIABLE CONDENSER—E. W. BREISCH, et al, of Edgewood Park, and LAWRENCE R. GOLLADAY, of East Pittsburgh, Pa. Filed July 24, 1925, issued Aug. 30, 1927. Assigned to Westinghouse Electric & Mfg. Co.

1,640,710—ELECTRON EMITTING CATHODE AND PROCESS OF PREPARING THE SAME—H. Miller, of Newark, New Jersey. Filed March 1, 1926, issued Aug. 30, 1927. Assigned to Hazeltine Corp.

1,640,929—PORTABLE RADIO ANTENNA—H. FARKOUH, of Brooklyn, N. Y. Filed Nov. 24, 1925, issued Aug. 30, 1927.

1,641,289—RADIO SIGNALING SYSTEM—RUSSELL S. OHL, New York City. Filed Nov. 23, 1925, issued Sept. 6, 1927. Assigned to American Telephone and Telegraph Co.

1,641,314—VARIABLE CONDENSER—HARRY L. BRADLEY, Milwaukee, Wisconsin. Filed Oct. 17, 1924, issued Sept. 6, 1927.

1,641,389—CONDENSER WINDING MACHINE—F. C. KROEGER and HARRY E. NORVIEL, Anderson, Ind. Filed July 29, 1922, issued Sept. 6, 1927. Assigned to Delco-Remy Corp.

1,641,395—RECTIFYING RADIO SHIELD—TOM MOORE, Cincinnati, Ohio. Filed Sept. 15, 1924, issued Sept. 6, 1927.

1,641,425—TRANSMISSION CONTROL—FRANK H. GRAHAM, Brooklyn, N. Y. Filed Oct. 24, 1923, issued Sept. 6, 1927. Assigned to Western Electric Co.

1,641,431—COMMUNICATION SYSTEM—JOSEPH W. HORTON, Bloomfield, N. J. Filed Dec. 15, 1925, issued Sept. 6, 1927. Assigned to Western Electric Co.

1,641,438—VARIABLE CONDENSER—L. L. JONES, Oradell, N. J. Filed Dec. 13, 1923, issued Sept. 6, 1927.

1,641,513—SUPPORTING MEANS FOR ELECTRICAL DEVICES—J. A. WARREN. Filed May 6, 1925, issued Sept. 6, 1927. Assigned to Dubilier Condenser Corp. (J. A. Warren, Mount Vernon, N. Y.)

1,641,593—MULTIPLE VARIABLE CONDENSER—FREDERICK A. KOLSTER, Palo Alto, Calif. Filed Apr. 28, 1926, issued Sept. 6, 1927. Assigned to Federal Telegraph Co.

1,641,608—ELECTRICAL SIGNALING—G. O. SQUIER, Washington D. C.; J. O. MAUBORGNE, Chicago, Ill.; and LOUIS COHEN, Washington, D. C. Filed June 24, 1922, issued Sept. 6, 1927.

1,641,635—ADJUSTABLE CONDENSER—R. M. KLEIN, New York City. Filed Nov. 1, 1924, issued Sept. 6, 1927. Assigned to F. A. D. Andrea, Inc.

1,641,687—VACUUM CONDENSER—H. J. NOLTE, Schenectady, N. Y. Filed Oct. 8, 1925, issued Sept. 6, 1927. Assigned to General Electric Co.

1,642,173—RADIO SIGNALING SYSTEM—H. J. ROUND, London, England. Filed Mar. 2, 1922, issued Sept. 13, 1927. Assigned to Radio Corp. of America.

1,642,350—TELESCOPING RADIO LOOP OR ANTENNA—L. ADAMS, Buffalo, N. Y. Filed Feb. 6, 1926, issued Sept. 13, 1927.

1,642,420—RADIO RECEIVING APPARATUS—S. LOEWE, Berlin, Germany. Filed Mar. 18, 1927, issued Sept. 13, 1927. Assigned to Radio Corp. of America.

1,642,498—ELECTRON DISCHARGE DEVICE—W. G. HOUSKEEPER, New York, N. Y. Filed Oct. 30, 1922, issued Sept. 13, 1927. Assigned to Western Electric Co.

1,642,522—LOOP ANTENNA—E. VROOM, Ossining, N. Y. Filed May 26, 1924, issued Sept. 13, 1927. Assigned to Western Electric Co.

1,642,526—MEANS FOR SUPPLYING POWER TO THERMIONIC VALVES—G. M. WRIGHT, Chesterfield, England. Filed Aug. 17, 1926, issued Sept. 13, 1927. Assigned to Radio Corp. of America.

1,642,663—SYSTEM OF RADIO COMMUNICATION—E. L. CHAFFEE, Belmont, Mass. Filed Aug. 11, 1922, issued Sept. 13, 1927. Assigned to John Hays Hammond, Jr.

1,641,945—ELECTRICAL INSTRUMENT—H. J. MURRAY, Brooklyn, N. Y. Filed Nov. 6, 1923, issued Sept. 6, 1927.

1,641,946—MOVABLE DIELECTRIC CONDENSER—H. J. MURRAY, Brooklyn, N. Y. Filed Jan. 29, 1925, issued Sept. 6, 1927.

1,642,011—LIGHT TELEPHONY—L. W. CHUBB, Edgewood Park, Pa. Filed June 15, 1921, issued Sept. 13, 1927. Assigned to Westinghouse Electric & Mfg. Co.

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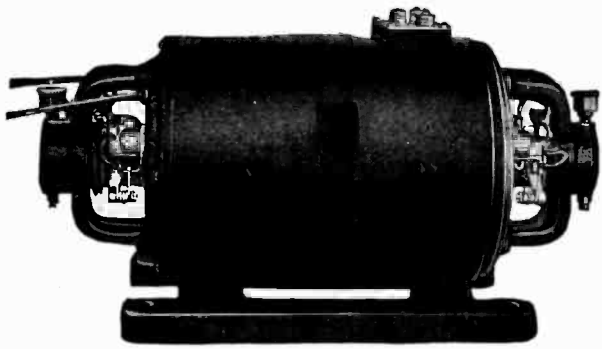

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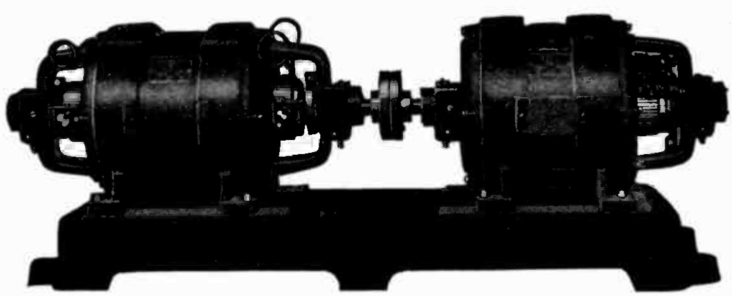

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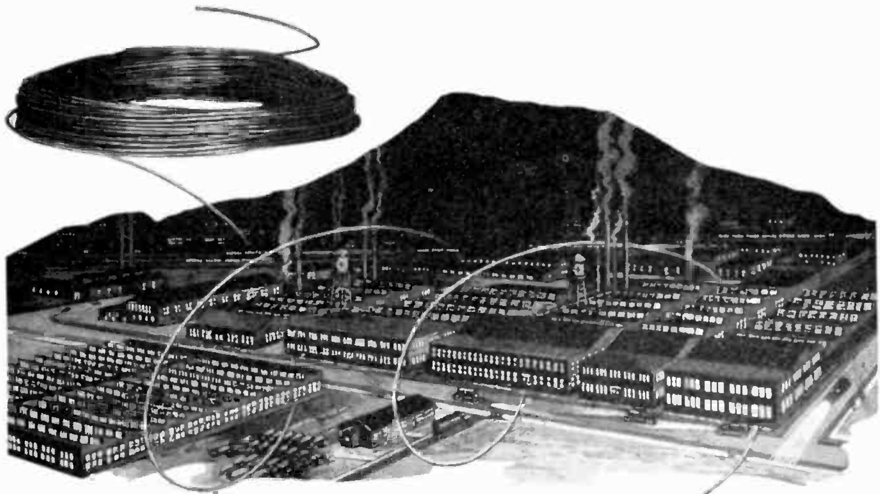

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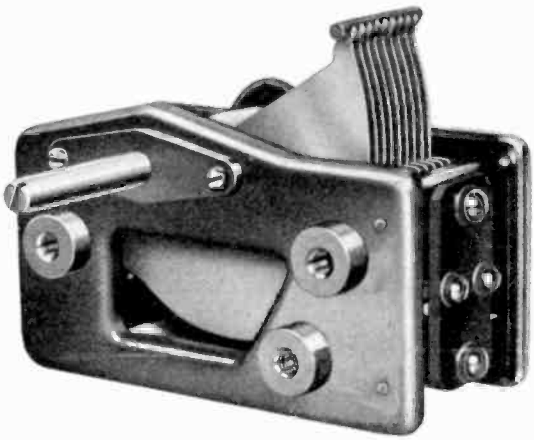

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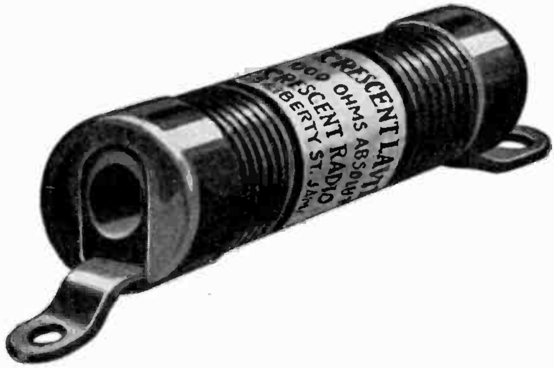

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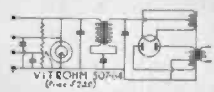

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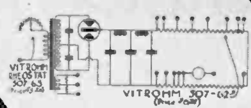

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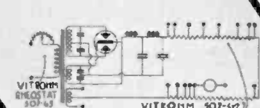

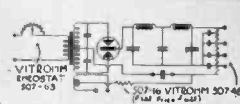

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