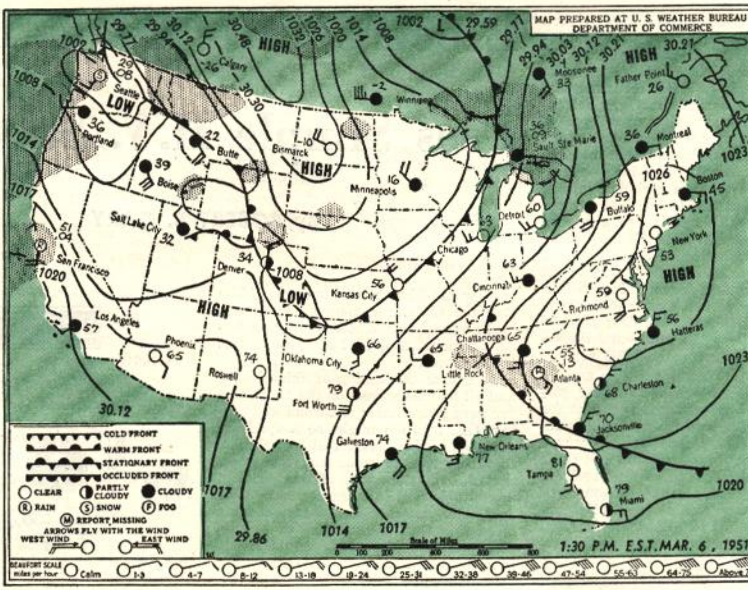

Large air masses, as those shown on this weather map, affect TV reception as they sweep the country.

WHAT'S THE MYSTERY BEHIND TELEVISION DX

By E. P. TILTON, W1HDQ*

THE TV viewer is often astounded and sometimes annoyed by pictures from distant stations on his TV screen. Sometimes they come in with such strength as to drown out local programs. Television viewers are divided into two camps—the dx hounds who are pleased and proud to receive programs from 1,000 miles or more away, and the local-station televiewers who object to the interference. The first group is much the larger, and many people are inquiring as to the whys and wherefores of long-distance television propagation.

As the first service to use the frequencies above 30 mc, the radio amateurs have contributed much to our knowledge of v.h.f. propagation. Amateur activity on 56-60 mc in the 10 years before the 1941 shutdown, and more recently in the new band at 50-54 mc, provided data on the lower TV channels. The high band is similar to the amateur 144-148 mc assignment, where thousands of hams have been working since 1945.

Long-distance propagation is considered a nuisance by commercial services. The ham, on the contrary, jumps at every opportunity for work beyond his normal communicating range.

There are many ways by which a 50-mc or higher-frequency signal can reach points beyond the normal working radius. Only two are important in TV reception. One is closely allied with weather phenomena and can be predicted with considerable accuracy 24 to 48 hours in advance. The other is the result of spotty concentrations of high ionization density in the E-layer region of the ionosphere, some 50 miles above the earth's surface. Its causes are not well known and consequently it is predictable only in a general way.

These two phenomena, *tropospheric bending* and *sporadic-E skip*, account for all the TV dx reported in recent issues of this magazine.

Tropospheric Bending

V.h.f. waves leaving the transmitting antenna take off into space in straight lines, so a television station's service area is a somewhat irregular circle of a diameter of perhaps 80 miles, depending on antenna height, transmitter power, nature of the terrain, receiver sensitivity, and other variables, including the weather at the time. The weather exerts an influence because the speed of radio waves varies with the dielectric constant of the medium they travel through. The temperature and humidity of air affect its dielectric constant, so our v.h.f. wave is bent slightly when it passes through a boundary between air masses having different temperature and moisture content.

Large masses of air are constantly moving across our country from west to east in fairly well-defined and predictable patterns. Modern weather forecasting methods are largely based on plotting of this air-mass movement[1]. Under stable weather conditions the boundary between two very different air masses may remain well defined for up to several days.

If this boundary lies along the path between a TV station and a distant receiver, a station may be received far outside its normal coverage. (Air-mass boundary bending can work the other way, too, reducing the coverage to below normal.)

The bending of radio waves by atmospheric stratification increases with frequency, but it is negligible below

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about 25 mc. The amateur 50-mc band is noticeably more responsive to tropospheric effects than is the 28-mc band, and the 144-mc band often shows strong signals from points several hundred miles distant, while 50 mc is only slightly affected. The distance over which refracted signals may be heard increases with frequency, *other things being equal*. 50-mc signals are seldom heard beyond 300 miles by tropospheric means (troposphere: the atmosphere between the stratosphere and earth, in which our weather occurs), but the 144-mc band often supports communication over distances up to 500 miles in the warmer months, and 700 to 800 miles is not uncommon. The current record for two-way amateur communication on 144 mc is nearly 1,200 miles.

From this we can see that the high-band TV channels, 7 to 13, should provide more tropospheric dx than the lower ones, channels 2 to 6. Why this is not borne out in current TV experience is easily understood when we consider the difference in performance of most receivers between the high and low channels. Most antenna installations favor the low band, and there is a preponderance of low-band stations. Channel 4 alone has almost as many stations on the air as all seven channels of the high band combined. (But we don't get as much dx on all seven channels combined as on channel 4. Perhaps there are a few propagation factors affecting 200-mc signals that are still not understood?—*Editor*)

Tropospheric bending occurs in all seasons, but is most pronounced in warm or mild weather, reaching its peak in most sections of the country during the fair calm weather of September and October. Large-scale air-mass movement is only one cause. Another is atmospheric convection that develops any warm sunny day along our coastlines, causing seaside locations to head the list of desirable homesites for the v.h.f. enthusiast, whether he be a communicating amateur or a TV set owner. The favorable season is longer in the more southern regions. The Gulf Coast, the Lower Mississippi Valley and the California coastal areas enjoy a considerable advantage in this respect. At the peak of the season, however, the broad reaches of the nearly flat Middle West states are favored with tropospheric bending hardly equalled elsewhere.

In addition to variations induced by weather changes, tropospheric bending follows a regular daily cycle. Early morning, when the sun heats the air aloft before the earth's surface temperature is affected, may be the best part of the day for v.h.f. propagation. (This knowledge is of little use to the TV enthusiast, transmitting schedules being what they are.) Of more practical value is the repetition of the temperature inversion in the period around sundown, when the earth cools more quickly than the layer of air immediately above it.

This daily cycle may be observed the year around, but when it is combined with other factors already enumerated we may have a truly phenomenal degree of bending on the frequencies above about 100 mc or so. This happens frequently along our coasts in May and June and September and October, and somewhat less often over inland areas. The turbulent weather of midsummer tends to dispel the air-mass boundary conditions most favorable to long-distance propagation, and cold weather discourages the coastal convection and diurnal factors. Tropospheric bending over distances beyond 300 miles is rare in winter.

The reports of observer Glaub of East Moline, Ill., of reception of WHIO-TV, Dayton, Ohio, channel 13, and WKRC-TV, Cincinnati, channel 11, on September 5, are typical examples of tropospheric bending on the high channels. Observer Swanson, Rockford, Ill., saw WSPD, Toledo, channel 13, on September 6 and 7[2] by the same air-mass condition. This period of three nights is of particular interest, as it was the occasion of the 144-mc work over nearly 1,200 miles mentioned earlier. Beginning just before midnight on the 6th an amateur in eastern New York worked several stations in Iowa, Missouri, and Kansas, and was heard in Oklahoma, more than 1,400 miles away!

Reception on October 30 of WJAR-TV, Providence, R. I., channel 11, by observer Canning[3] of Halifax, Nova Scotia, is an example of the coastal type of opening. This sort of thing could be done much more often than is generally appreciated if the 144-mc experience of Halifax and Yarmouth amateurs is any indication. A Yarmouth man has found it possible to work as far south as Norfolk, Va., fairly often, and his best dx, Fayetteville, North Carolina, about 900 miles, was worked with signals of tremendous strength. Even though the power level of amateur stations is far below that of the most modest high-band TV station, signals over such distances are often well above that required to provide a good TV picture on a reasonably sensitive receiver. There is little doubt that high-band TV dx could be logged much more often if viewers knew when to be on the lookout for it.

The practical receiving range for low-band stations can be extended appreciably by the use of properly designed r.f. amplifiers and antenna systems, as demonstrated by observer Dubreuil[4] of Lavaltrie, Quebec, who has succeeded in receiving WRGB-TV, Schenectady, and WSYR-TV, Syracuse (channels 4 and 5) consistently, over a 260-mile path.

Sporadic-E Skip

Practically all low-band TV dx beyond 400 miles is the result of reflections in the E-layer region of the ionosphere. As such it is markedly different from tropospheric bending. The experienced observer should have no trouble in distinguishing between the two phenomena. Because the reflection takes place many miles above the earth there is a *skip zone* of several hundred miles in which the signal is not ordinarily heard. Sporadic-E skip reception is most common over distances of 600 to 1,300 miles, though exceptionally intense ionization may bring the minimum skip down to as low as 300 miles, and multiple-hop effects can extend the coverage to 2,500 miles or more.

At times there appears to be a tie-in with observable weather effects, but the correlation is not well established, nor is the exact cause of the phenomenon completely known. After years of observation by amateurs and scientists, prediction of sporadic-E is still only

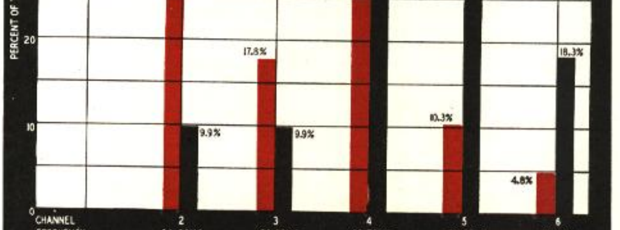

Fig. 1—This tabulation, compiled from 146 dx reports in RADIO-ELECTRONICS, illustrates the effect of increasing frequency on the occurrence of sporadic-E layer skip. The red columns show the percent of total reports, the black show the percentage of the total number of stations on each TV channel in the U.S.

partially successful. We do know quite a bit about it in a general way, however. We know that it can develop at any hour, in any season, but that it is most common in the mid-day and early-evening hours of the six-week period either side of the longest day of the year, or from early May to the middle of August. There is a minor period from early December to the middle of January.

Ionization sufficiently dense to reflect signals on frequencies up to 60 mc or more is very frequent in the May-to-August period, and the signal strengths encountered at times are nothing short of astounding. This explains the occasional dx reception reports from viewers having small receivers and indoor antennas. As an example, an observer in New England, in the fringe area of WCBS-TV, New York, may find his channel 2 reception taken over by WSB-TV, Atlanta, WJBK-TV, Detroit, WFMY-TV, Greensboro, North Carolina, or even KPRC-TV, Houston, Texas, instead of his customary New York program. Or the interference may be only strong enough to cause the uninformed viewer to call his repairman.

Examination of 146 low-band dx reports in recent issues of RADIO-ELECTRONICS shows them to be of sporadic-E origin. The times of reception, where given, agree closely with amateur 50-mc observations for the same period, and every date listed is one on which amateurs were making sporadic-E contacts over roughly the same paths.

From amateur experience on 28, 50, 56, 112, and 144 mc, and from observation of skip effects in the FM band, 88 to 108 mc, we know that sporadic-E drops off sharply with frequency, being relatively rare above about 100 mc. The top frequency is not precisely known, but it seems unlikely that high-band TV channels are ever affected.

This drop in sporadic-E with frequency is apparent in Fig. 1, even though the chart was compiled from a relatively small mass of data. From it we see that channel 2, with less than 10% of the country's stations, accounted for more than one-fourth of the reports. Channel 3, with the same number of stations, netted only 17.8% of the reports. Nearly 42% of the reports were for channel 4 stations. This slightly inconsistent figure (channel 4 having 39.4% of the stations) is easily explained. The presence of many more stations, with better distribution over the country, makes for more monitoring of that channel, and more antenna installations favoring it. Reports for channels 5 and 6 are greatly in the minority, though 45% of the country's stations are operating there.

Other causes of v.h.f. dx

Though tropospheric bending and sporadic-E skip account for nearly all the TV dx thus far observed, other factors can enter the picture. There is a very slight possibility of reflection from the ionospheric F2 layer. The reception of BBC television by Henry Rieder, of Capetown, South Africa, in 1947 and 1948 was in this category. This is a daytime phenomenon exclusively, and it is possible only near the peak of the 11-year sunspot cycle. Even then (the peak was in February, 1948) it is doubtful whether the upper frequency limit of F2-layer propagation is high enough to affect American TV stations. Note that the BBC video is on 45 mc, the sound on 41.5 mc. The writer received both frequencies often in October and November, 1946-48, but the video has been heard infrequently since. The sound was heard well a few times in 1949, but not at all in 1950. There is practically no possibility of transatlantic TV reception again before 1957 or 1958, at the present state of the art.

V.h.f. waves can be bounced back by the aurora borealis. Swing your TV array around to the north the next time an aurora lights the skies. Because of the scattered nature of the reflected signals there may be severe multipath distortion of the reception, and signals so reflected are generally rather weak. Try all the channels, however—you may be in for some surprises!

Anticipating favorable conditions

Armed with the above facts we can examine the TV dx reports so far published in this magazine and say, with some assurance, just how each of them happened. Better, we can look ahead and see when such things are likely to happen again.

Because tropospheric openings are closely related to weather conditions, we can spot them several days away if we study the weather across the country in detail. This can be done fairly well by watching the weather maps that are published in many newspapers. The type showing pressure distribution is best for our purposes. If a large high-pressure area is shown moving slowly across the country we can be almost certain that improved propagation will accompany its passing our locality. The best tropospheric bending is almost always closely associated with the middle or the trailing edge of a large high-pressure movement.

It is not the barometric pressure gradient that causes the bending, but rather the atmospheric stratification that accompanies it. The pressure lines on the weather map, called isobars (or lines of equal barometric pressure) are merely a convenient indicator as to when and where favorable conditions may exist.

We can do fairly well at short-term prediction of tropospheric openings if we do no more than watch the local weather. Temperature and barometric pressure changes, the wind direction, visibility, changing cloud forms—these are weather signs by which man has predicted the weather for generations, long before the advent of weather maps or television. They are still good for local forecasting, and for guessing when better TV reception is in prospect.

Some favorable signs: High barometer, after a slow rise. Thin high cloudiness, and little or no wind. Ground fog in the early morning, or late at night. Cumulus clouds forming around mid-day, but not mushrooming into thunderheads. A weather forecast for rain after a protracted fair spell in summer, or snow turning to rain in winter.

Prediction of sporadic-E skip is something else again, for the best minds in the business have not yet been able to do it with any reliability. We know when it is most likely to happen, and we can recognize it when it breaks, but it still pulls some surprises on us that don't fit in with previously observed patterns.

A classic example is the case of January 4, 1951. Beginning about 7:15 pm EST, sporadic-E skip began to break out over most of eastern United States and Canada. The area affected ranged from Nova Scotia to Florida, and from the Atlantic to well past the Mississippi. An amateur friend of the writer, in Yarmouth, N. S., taking time out from his rapid succession of dx contacts on 50 mc, found signals jamming his TV set on all channels from 2 to 6. The jumble was such that it was difficult to identify any one station. This was 300 miles from the nearest TV transmitter—and in midwinter!

Catching a major portion of the sporadic-E openings the year around takes frequent observation and not a little luck, but the ionosphere does drop a few clues. Begin checking in earnest in late April, particularly around 7 [illegible] 9 pm. If you have a receiver covering the amateur bands at 28 or 50 mc watch out for signs of "short skip" communication. If 28-mc stations are heard working distances of 300 to 1,200 miles there's a good chance that at least channel 2 may be open over the same paths. If 50-mc stations are heard similarly, several channels are probably open.

Make a note of any open dates. As sporadic-E is related to solar conditions in a general way, there is likely to be a recurrence of any pronounced opening in about 27 days, the time Old Sol takes to make one complete turn on his axis. There are usually two major openings each month, about two weeks apart, and once those periods are established there is a good chance that repeat performances can be caught the following months on similar days, four weeks later. The average solar disturbance will remain active for at least three solar rotations.

Probably the most important adjuncts to improved dx reception are a sensitive receiver and a high-gain antenna system. The best openings can be caught on any kind of gear, but a low-noise front end of adequate gain, and a properly designed antenna system equipped with a rotator will bring in dx signals many times when the average installation shows no sign of life what[illegible]

REFERENCES

1 Modern aerological techniques have been the subject of many popular texts in recent years. One recommended by the author is **Weather and the Ocean of Air**, Wenstrom, Houghton Mifflin Company.

2 *Radio-Electronics*, December, 1950, page 27.

3, 4 *Radio-Electronics*, January, 1951, page 69.

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