# TWENTY-ONE YEARS OF TE

## *An account of observations and experiments in transequatorial radio propagation conducted between 1957 and 1979 using frequencies from 28 to 432MHz*

### (PART 1)

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## Summary

*The transequatorial propagation of 144MHz radio signals between Salisbury and Limassol during the period April 1978 to May 1979 is examined in the light of earlier te observations and experiments. Important clues to determining the supporting mechanism are provided by detailed reception reports of beacon transmissions in the 28, 50, 144 and 432MHz amateur bands, and by time delay measurements, observations of the variable angles of arrival and examination of the flutter fading and frequency spreading characteristics of the received signals.*

*Propagation is shown to occur at frequencies at least as high as 432MHz over distances of 5,000-8,000km across the equator in years of high sunspot activity. The reliability of propagation at 144MHz is considerable, especially in the appropriate seasons which, over Africa, are displaced somewhat from the equinoxes. Evidence is produced to confirm that propagation does indeed take place via the ionosphere and that, although the mechanism is complex, no phenomena that cannot be explained by changes in the night-time tropical ionosphere were observed.*

## The background

In September 1957, ZC4WR joined the amateur radio net which with ZE2JV was discovering the presence of a night-time propagation path of extraordinary reliability between Salisbury, in what was then known as Southern Rhodesia, and Limassol, on the island of Cyprus, on frequencies of 28, 50 and 70MHz [1]. The renewal of an old friendship led to the systematic recording of ZE2JV's 50MHz automatic transmissions throughout the International Geophysical Year (IGY), January 1957-December 1958. The results attracted considerable interest and led to an internationally financed project [2] which demonstrated that, even as late in the sunspot cycle as 1961-2, frequencies up to 90MHz were usable.

The authors then prepared for the following sunspot minimum during the International Quiet Sun Year (IQSY) when beacons were run on 29 and 50MHz. Propagation at 50MHz still took place but with considerably reduced regularity, although at 29MHz the reduction was less apparent [3]. ZC4WR had a spell on St Helena, where he set up a ZD7WR beacon on 29MHz, while ZE2JV, working with ZE3JJ and other members of the Radio Society of Rhodesia, set up beacons on 1·8, 50 and 70MHz. After a couple of years in England, Roland returned to Cyprus as 5B4WR, and contacts with ZE2JV were renewed.

In 1978, as a result of reports of 144MHz contacts by te in South America [4] and the reception of the 145·9MHz beacon of the Oscar 7 satellite when it was well below the southern radio horizon from Athens and Cyprus, the authors were prompted to undertake a systematic investigation of the Limassol-Salisbury circuit at 144MHz. Costas Fimeralis, SV1DH, and George Vernardakis, SV1AB, both in Athens, joined in the tests. The first to hear a 144MHz signal out of Africa south of the equator was Nick Kyriakis, 5B4AZ, in Limassol, on 8 April 1978 from 1726 to 1810gmt, and he alerted 5B4WR who also heard the automatic transmission from ZE2JV. Signals were again heard on 9 April, and on 10 April the first 144MHz QSO between 5B4WR and ZE2JV took place. On 12 April ZE2JV worked SV1AB, and this was followed by QSOs with SV1DH and SV1CS a few days later.

The monitoring of ZE2JV's automatic transmissions on 144MHz had commenced in Cyprus on 21 March 1978. The frequency of transmission had been accurately determined and receivers at 5B4WR and 5B4AZ had been carefully set on the frequency, waiting for the signal to appear. In retrospect it is not surprising that nothing was heard for over two weeks, for we had forgotten or discounted the equinoctial drop-out of maximum usable frequency (muf), a phenomenon well recorded in muf curves published 20 years ago[1].

Later in 1978 the group was joined by ZS6LN and ZS6PW. Their contribution was particularly welcomed because the South Africans still had use of the 50MHz band. Dr Fred Anderson, ZS6PW, was a long-standing member of the te group, and worked with the authors as ZS1LA from Worcester in the Cape Province of South Africa during and after the IGY. Test transmissions on a regular basis were started by both stations, and the Cyprus VHF Group activated 5B4CY as a 50MHz beacon in September 1978.

Inspired by ZS6PW, a group of Pretoria amateurs, calling themselves the Tessa group, combined their efforts to establish a 144MHz beacon station at the QTH of Dave Larson, ZS6DN. It was first heard in Athens in February 1979. Within a few days ZS6DN had QSOs with SV1DH and SV1AB; at the time of writing the second was still standing as the world record for a contact via the ionosphere on 144MHz. However, on 30 and 31 March 1979 I4EAT heard ZS3B, and on 31 March ZS3B also heard I4EAT. No fully-intelligible QSO was completed but signals were positively identified both ways and recorded over a distance of more than 8,000km. (The strength of the signal recorded by I4EAT, as heard played back over the air on 28MHz, would seem to suggest that even this is not the limit and that Britain or Scandinavia to the Cape of Good Hope should be the ultimate target for amateurs on 144MHz.)

Transmissions on 432MHz commenced from ZE2JV on 18 March 1979, and two days later the signal was copied by both SV1DH and SV1AB from 1816 to 1830gmt. The signal was described as being rougher and spreading in frequency more than the 144MHz signal being received simultaneously, but was, according to SV1AB, "definitely QSA5". Nothing more

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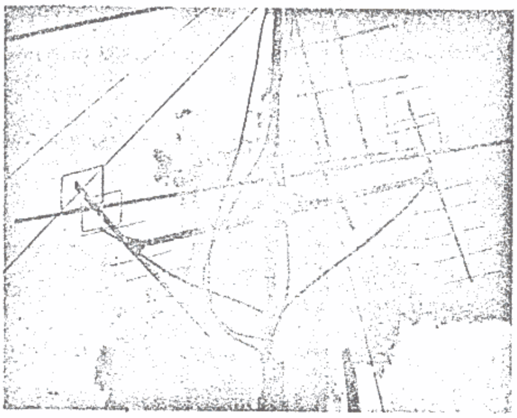


The 432MHz quagi beam used by ZE2JV for the first successful te tests. Parts of the 3-element 28MHz and the 11-element 144MHz Yagi beams can be seen higher up the mast (*Photo:* ZE3JJ)

was heard during the equinoctial drop-out period from 22 March to 8 April. The Cyprus group equipped themselves for listening on 432MHz, and on 13 May the signal was heard and positively identified by 5B4WR.

There were several other minor openings to Greece and Cyprus, and there can be no doubt that te QSOs on 432MHz are possible.

While working QSOs is the main aim of all amateur radio endeavour, over the years propagation phenomena have become the motivation for the numerous QSOs, tests and measurements which the authors have conducted. In previous articles they have resisted the temptation of advancing any novel theory to explain the phenomena which they have been privileged to witness and identify. However, against the weight of a considerable body of academic opinion, the authors established beyond all reasonable doubt, in 1959, that trans-equatorial propagation (tep) does take place via the F-regions of the ionosphere. They have consistently maintained that the propagation phenomena are directly related to changes in these regions after dark, and that only a thorough understanding of these changes can lead to an understanding of tep, although at the same time a study of tep can give important clues regarding the morphology of the ionosphere which supports it.

## Methods employed

### Automatic transmissions

The basic method for the investigations has been the provision of a consistent transmission schedule with monitoring at the receiving end. Strictly speaking, many of the transmissions should not be termed beacon transmissions but would be more correctly described as test or experimental transmissions, since they are operated on "as required" schedules, often use directional antennas, carry varied information, and can be interrupted in order to work QSOs.

The authors have provided some true beacons, and among these are the present 5B4CY beacons run by the Cyprus Amateur Radio Society VHF Group on 28, 50 and 144MHz; the earlier ZC4WR and ZD7WR beacons on 29MHz; the ZE1AZC beacon which ran for nearly six years on 50MHz, ZE1AZD on 1·8MHz, ZE1AZB on 70MHz and the ZE2TEP transmitters [2] which ran on five frequencies between 30 and 90MHz.

Continuous monitoring using pen, Rustrak and sampling tape recorders was usually employed with the true beacons. However, because of low signal strengths and the number of separate transmissions to be monitored, the Athens and Cyprus monitoring stations on 144 and 432MHz preferred to listen directly from their receivers: automatic recording provides interesting records of signal strength variations but is no match for the human ear when receiving weak signals.

Transmissions from ZE2JV on 28·331 (now changed to 29·226), 144·160 and 432·480MHz, and from ZS6DN on 28·315, 144·129 and 432·460MHz are test transmissions, although they are operated on widely publicised schedules and are listened for by a growing number of enthusiasts in southern Europe.

### Time-delay measurements

Clearly an important clue to solving the mystery of any anomalous propagation is the time taken for the signal to travel from transmitter to receiver. In 1960 the authors published the results obtained by transmitting pulses, rebroadcasting them from the receiving station and photographing the outgoing and returning pulses together with a timing scale from a cro [5]. The results obtained are reproduced in Table 1. For practical reasons arising from the nature of the 144MHz signals, it was decided to take the 1960 measurements as valid for the time being and to do comparative time-delay measurements by pulsing ZE2JV's transmissions on 28 and 144MHz simultaneously and to use simultaneous keying of the 5B4CY transmissions on 28 and 50MHz. At first stereo recording was attempted but errors were found to result, so the authors resorted to recording on a single tape with beat notes well separated in frequency for later analysis by ZS6PW on a sonograph.

More sophisticated time-delay tests are being planned between Pretoria and Athens, where universal time standards can be obtained, but the results of these tests will not be available for some time to come.

### Angles of arrival

A further important clue should be provided by determining the angles of arrival in the horizontal and vertical planes, but doing this with any real degree of accuracy is much more difficult than is often realized. The long Yagi has a relatively broad front lobe, and the sharper null in the broadside position is not usable on weak signals. Nevertheless the rotatable Yagi is a useful, if rather crude, tool, and valuable for comparative tests in the horizontal plane. In the vertical plane tiltable Yagis provide even more questionable results due to ground effects and reflections from buildings and power lines, but these impediments seldom change from day to day and variations can be attributed to variations in the angles of arrival of signals with a reasonable degree of confidence.

Beam rotation tests soon reveal that in optimum locations for tep, such as Athens, Limassol and Salisbury, beams tend to lose their directivity in a random fashion. In order to investigate this phenomenon, in 1958–9 ZE2JV transmitted a plain carrier on 50MHz from a four-element Yagi that was pointed first north, then east, south and west, and the received signal strength in each position was recorded in Limassol by ZC4WR. The results varied from a "normal" (say, 7-1-3-1) to a complete loss of directivity (say, 7-7-7-7). Tests were continued for over a year. Correlations were then sought with the degree of flutter fading, the incidence of tropical storms, solar

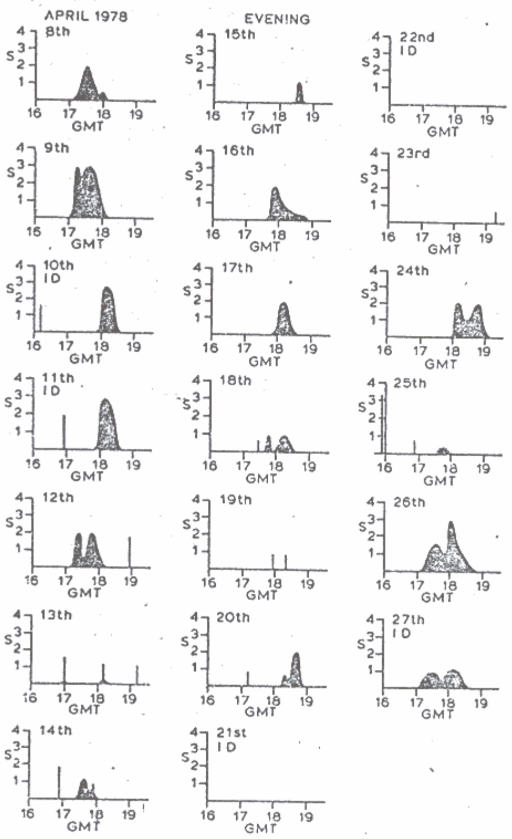


Fig 1. Reception of ZE2JV, Salisbury, on 144·118MHz in Limassol by 5B4WR

disturbances, and the results of a meteor scatter count experiment that was being run concurrently. All of these proved to be only randomly related to loss of beam directivity, which was, however, found to correlate strongly with the spread of te signals southward towards the Cape of Good Hope.

More recent experiments have been directed at determining the vertical angle of arrival of 144MHz te signals. SV1AB experimented with a tiltable eight-element Yagi, and at times found the optimum angle with his beam to be at 20°. 5B4WR compared results on his 12-element Yagi, which had excellent low-angle visibility to the south across the Mediterranean, with those on a vertical 3λ/2 in-phase antenna, and often found that the expected extra gain of the Yagi was not realized. Further, 5B4AZ often received slightly stronger signals than 5B4WR, although his beam was only 2m above a reinforced concrete roof and the direct view to the south was obscured by a large water tank.

Although the results were inconsistent and the angle of arrival seemed to vary randomly in the same manner as beam directivity, ZE2JV elevated the antenna used for the first successful 432MHz tests at an angle of 15°. Whether or not this was an optimum angle is unknown, as the antenna shown in the photograph was deliberately designed to have a relatively broad vertical angle of radiation.

### Examination of the fading patterns

One of the most striking characteristics of tep is the often observed presence of flutter fading which gives the received signal a quality similar to that of signals reflected from the aurora. It is, however, incorrect to assume that te signals always carry flutter fading. Such fading can sometimes be heard on signals as low in frequency as 6MHz. Similar characteristics occur as scintillations on radio stars and affect signals from satellites if the signals pass through an affected area of the ionosphere.

Earlier efforts were directed unsuccessfully at relating the degree of flutter fading to the observed signal strength, the mode of propagation and, as already mentioned, the loss of beam directivity and the other phenomena observed simultaneously.

Fading patterns were recorded for analysis at Stanford University and photographed from cro displays of received carriers under various conditions; a number of examples of these

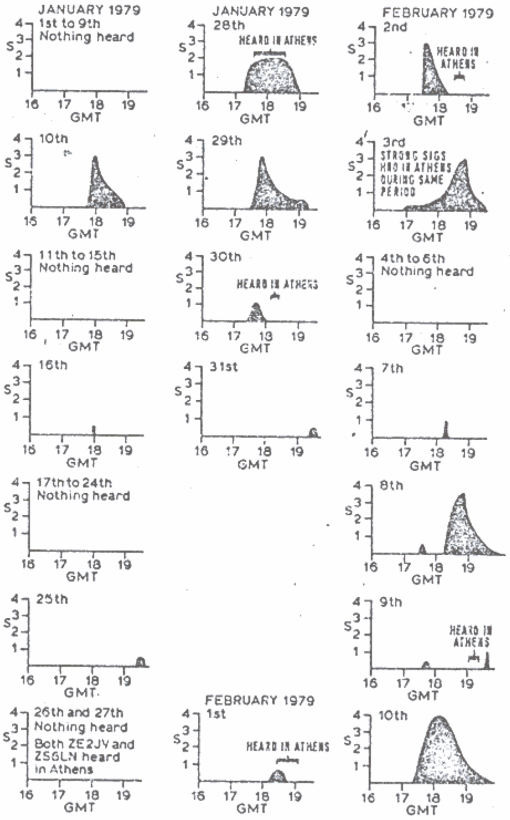


Fig 2. Reception of ZE2JV on 144·16MHz by 5B4WR

appear in [1]. In this article the authors have concentrated upon the analysis of simultaneously transmitted and received signals on 28 and 144MHz, and on 28 and 50MHz, using the same techniques as for the time-delay measurements.

With the use of higher frequencies in the 144 and 432MHz bands, the associated phenomenon of frequency spreading becomes more apparent. Doppler shift, resulting in the returned signal being lower in frequency than the outgoing signal received simultaneously, has been observed on backscatter signals both from ZE2JV and from the 5B4CY 144MHz beacon. It has been suspected on te signals but not proven. This is an obvious experiment for the future but will require frequency stabilities better than those of the crystal oscillators used in amateur equipment.

## Apparatus

The transmitter power required for successful tests at 144MHz was found to be of the order of 100W rf output into a well-matched antenna system. Below this level the apparent duration of an opening was substantially reduced, although under the best of conditions very-low-power transmissions could be heard. ZE2JV's test transmissions were therefore operated at approximately 200W, except in off-peak listening periods when the power was reduced to 40W.

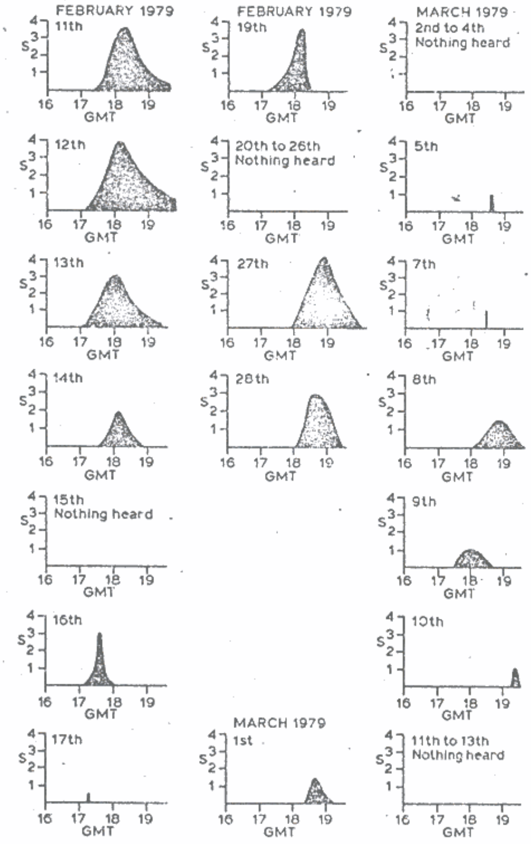


Fig 3. Reception of ZE2JV on 144·16MHz by 5B4WR

The antennas employed by 5B4WR, 5B4AZ, SV1DH, SV1AB and ZE2JV were all single long Yagis using from 11 to 16 elements for the 144MHz tests. The choice was fortuitous, as propagation takes place over a broad front and not necessarily in a direct line from transmitter to receiver, with a vertical angle often higher than previously anticipated, so that stations with big arrays and stacked beams may well be at a disadvantage on occasions.

The Cyprus, Athens and ZE2JV terminals all used solid-state converters, except that for the early QSOs ZE2JV used a tube converter with a 6CW4 nuvistor preamplifier. As with lower frequencies, when ionospheric openings occur there is a pronounced rise in received noise, and extreme measures to reduce the noise figure of converters to below about 2dB would not appear to be worthwhile. Similarly on cw, due to the frequency spreading often experienced on 144 and 432MHz the use of filters more selective than about 2kHz may not improve reception, and the usual ssb crystal filters in the i.f. were found to be about optimum for te work.

On 432MHz ZE2JV transmitted with a power of 40W measured at the antenna, which consisted of two colinear eight-element quagis. The antenna was only about 5m above ground, with the 28 and 144MHz beams higher up the mast. In the photograph the simple arrangement for tilting the quagi array can be seen, and further experiments with it are contemplated.

## Results obtained

The results of a year's patient monitoring by 5B4WR and 5B4AZ have been drawn up on a day by day basis and a selection of these is illustrated in Figs 1–4, showing both signal strength and the duration of the openings. From these it can be seen that openings sometimes lasted for up to 2h or even more (11, 12 February 1979, for example) centred around 1800gmt (8pm local time). The high-power (200W) transmission was normally operated from 1730 to 1930gmt. However, the restricted hours of high-power transmission and of listening seem to have had little effect, except on 11, 12, 13 February 1979 where the actual time of closure could be interpolated from the graphs.

In Fig 5 these results are summarized and plotted against solar rotation periods. Some evidence can be drawn from the diagram to suggest that good periods of openings depend on solar activity and may be repeated on the next solar rotation, but the evidence is far from conclusive. Considerable effort has similarly been expended in trying to correlate openings with geo-magnetic activity and solar flux. Results were promising at first, but were later found to be applicable in only about 50 per cent of cases, and then only during the period immediately before a magnetic storm. In general it may be said that a high solar flux and low magnetic index are usually prerequisite for 144MHz openings. It is also evident that the detrimental effects of magnetic storms are more noticeable on 144 than on 50MHz, while at 28MHz propagation between Limassol and Salisbury was rarely interrupted by magnetic or ionospheric disturbances. The beneficial effect of solar activity was more noticeable in off-peak seasons and in periods of low solar flux, when an increase in ionization may make propagation at 144MHz possible, but in the peak seasons only the disruptive effect of storms was apparent.

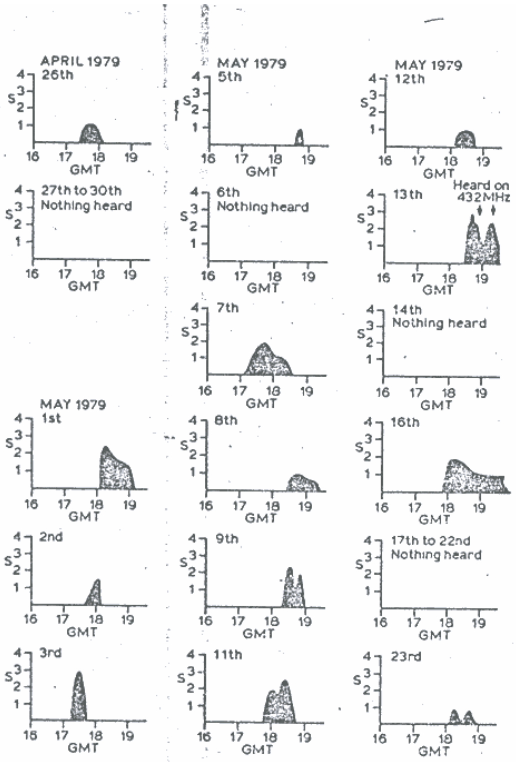


Fig 4. Reception of ZE2JV on 144·16MHz by 5B4WR

Defining the peak seasons as the equinoxes and the off-peak seasons as the solstices was found to be an over-simplification. The June–July solstice was the longer and more pronounced off-peak season, and the best conditions occurred during the period lasting from mid-February to early May, and for a shorter period in October–November.

In spite of the fact that openings at 50 and 144MHz did not always take place simultaneously, and that 144MHz propagation took place on several occasions when 50MHz was not open, the evidence gathered tends to point to the same type of propagation being involved at 28, 50 and 144MHz, and probably at 432MHz as well. Evidence leading in this direction includes the following:

### Geographical zones

The zones where te signals at 28 and 50MHz come down with greatest reliability and signal strength are identical to the zones of maximum reliability at 144MHz. Reference to the map published in *QST* (December 1959, p12) and the *ARRL VHF Manual* (1st edn, p21), and reproduced here as Fig 6, will show that Cyprus and Athens are right in the middle of the main zone to the north as seen from Salisbury. Further, the most westerly report of reception of ZE2JV's 144MHz signals was from the Spanish island of Ibiza, and the most easterly from Israel, giving a 144MHz zone fitting very neatly in the middle of the 50MHz zone as drawn 20 years ago. The same snug fit applies to the zone as seen from Athens and Limassol.

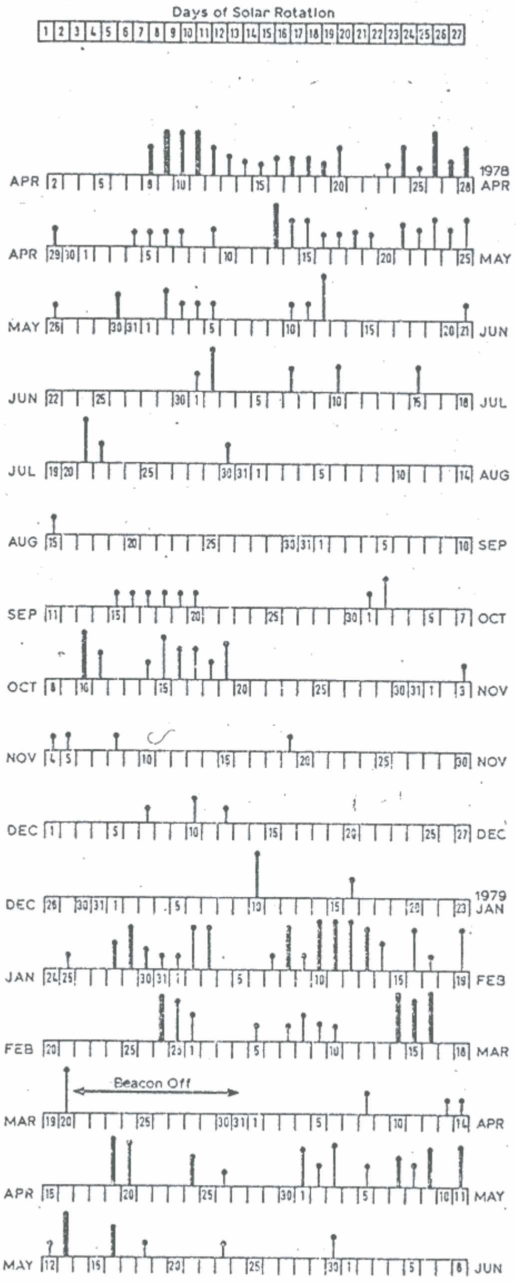


Fig 5. Reception of ZE2JV on 144·16MHz by 5B4WR during early evening (1630-1930gmt) plotted against solar rotation periods. Line thickness indicates duration: line height indicates intensity of the openings

### Seasonal variations

The seasons for the best and the worst propagation conditions show a considerable measure of agreement at 28, 50 and 144MHz. There is the anomaly of the equinoctial drop-out which affects all signals above 50MHz and it is interesting to note that this may be a peculiarity of the Europe–Africa te circuit, probably caused by the southern African magnetic anomaly which gives the whole of the area from the Zambesi to the Vaal rivers high magnetic dip angles. (Salisbury and Pretoria have dip angles of something like 57°.) The ionosphere is strongly influenced by the earth's magnetic field, and symmetry about the magnetic equator appears to be a prerequisite for tep to take place.

Curves showing the monthly variations in reliability for the period September 1978–August 1979 are illustrated in Fig 7. The similarity of the curves for the British 28MHz beacon GB3SX and the Cyprus 5B4CY 50MHz beacon is striking. The effect of the equinoctial drop-out at 144MHz is illustrated, and would be even more pronounced if periods of less than a month were taken. Figures for the Japan–Australia circuit, although not strictly comparable as the January–June figures are for 1978, not 1979 as in the other curves, show no equinoctial drop-out effect. If the effect of the drop-out is removed from the 144MHz Cyprus–Salisbury curve, the correspondence between 28, 50 and 14MHz is marked.

It is interesting that every month of the year showed at least one opening on 144MHz between Salisbury and Limassol. The lowest was in August 1978, with only one opening of 10min on the 15th, but August 1979 showed a considerable improvement (10 openings).

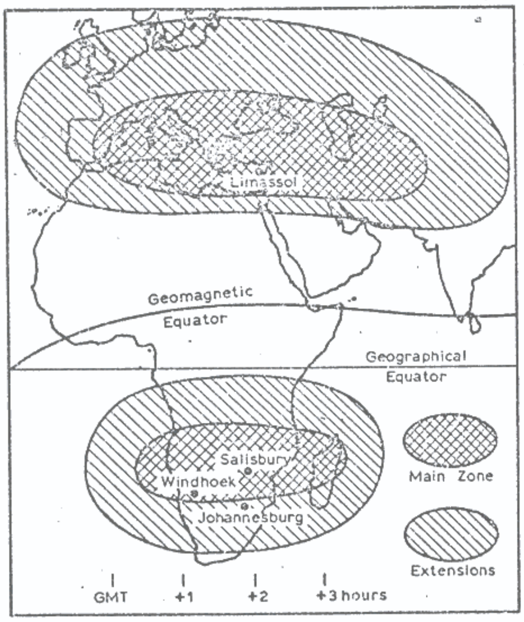


Fig 6. The te zones at 50MHz as seen from Limassol in the north and Salisbury in the south (source: *ARRL VHF Manual;* 1965). At 144MHz the respective zones fit neatly inside the main zones at 50MHz

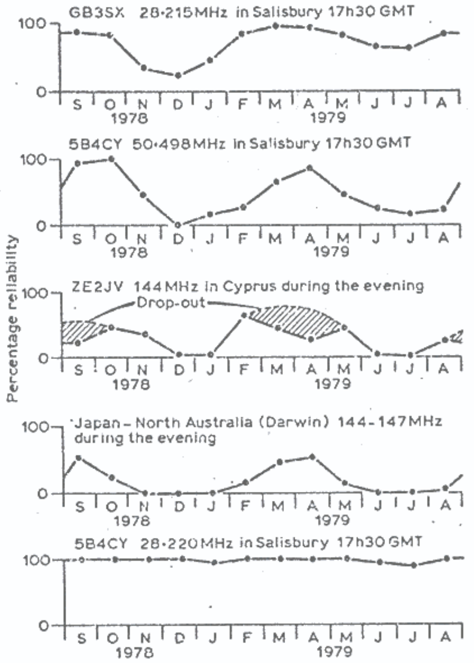


Fig 7. Seasonal variations in reliability of various te circuits. The effect of the equinoxial drop-out is evident in the Salisbury–Cyprus 144MHz results

### Time-delay measurements

The 1959 time-delay experiments summarized in Table 1 showed a slightly longer time delay than could be expected from the proposed ray geometry (about 4ms longer for the round trip from Salisbury to Cyprus and back). These results obtained 20 years ago lacked the precision obtainable at the present time. However, pictures taken during the afternoons occasionally showed shorter delays which corresponded closely with the expected delay for two-hop $F_2$-layer propagation, and the stronger evening tep signals were clearly taking about 10 per cent longer. This extra time has to be taken up either by an extra ray path distance of some 600km each way, or in the propagation mechanism itself.

Fig 8 shows a sonograph analysis of the simultaneous recording of the two 5B4CY beacon transmissions on 28 and 50MHz received by ZS6PW in Pretoria. In his note accompanying this print, Dr Anderson stated:

". . . I include sonograms of simultaneous recordings on 6 and 10. You will note that there is no extra delay great enough for my system of analysis to show. If any, it is probably less than 2ms."

In Fig 9 the callsign and pulse train transmitted simultaneously on 28 and 144MHz from ZE2JV and recorded by SV1AB in Athens are displayed. ZS6PW's comment on this sonogram was:

"Note many examples of coinciding 10 and 2 metre pulses and no positive indication of non-coinciding pulses."

**Table 1. Results of time-delay experiments conducted in 1958–9 published in 1960**

| Circuit | Time local | Great circle distance (km) | Time delay (return) (millisecs) | Elongation at fade out (millisecs) | Suggested mode of propagation |
|---|---|---|---|---|---|
| Salisbury—Limassol (50, 29·5 and 28MHz) | 1800-1900 | 5,792 | 40·5 | 1·0 | $2F^2$ |
| | 1830-2000 | | 44·5 | 5·0 | F-type te |
| | 2100-2200 | | 45-55 | Diffused | Pure te |
| Salisbury—Worcester (SA) (28 and 29·5MHz) | 1100-1700 | 2,144 | 15·3 | 0·5 | $1F^2$ |
| Worcester—Limassol (28 and 29·5MHz) | 1830–1930 | 7,680 | 57·5 | 1·5 | F-type te |

Fig 9(a) shows an enlarged version of simultaneous 144 and 28MHz pulsing made on the same evening (2 February 1979).

Here it must be recorded that not all the 28 and 144MHz recordings provided an unequivocal picture. Some of those from Cyprus seem to suggest varying delays, but even with these the authors can find no evidence that, on average, there is any greater delay on 144 than on 28MHz. Neither does another recording made by SV1DH on 13 February, reproduced in Fig 10 with a part enlargement of pulses in Fig 10(a), show any significant difference in delay time. Difficult though these measurements have proved to be, the tentative conclusion is that within the accuracy of the method employed the delay time over the te circuit remains independent of frequency from 28 to 144MHz.

### Patterns of fading

It is evident from the sonograms in Figs 8 to 10 that signals received on different frequencies simultaneously from the same location may differ in their character. From the recording illustrated in Fig 11 the more rapid fading on 50MHz is clearly apparent and its chopped nature is evident. Slow chopping on 28 or 50MHz can, at times, make it almost impossible to read morse code from a cw transmitter. On 144MHz the chopping rate is usually much faster so that the signal sounds rough and cw appears with a raw ac note, while frequency spreading has made the received signal as wide as 2kHz or even more. However, it is important to note than these effects are not consistent and the character of the received signals may vary considerably from day to day and hour to hour in a somewhat random manner. On SV1AB's recording illustrated in Fig 9 it is interesting to notice very similar signals on 28 and 144MHz, while that from SV1DH in Fig 10 shows an F-type signal on 28MHz and frequency spreading of up to 2kHz on the 144MHz signal. Very rarely has a cleaner signal appeared on the higher frequency, although a rapidly chopped signal on 144MHz may be much easier to read on cw than a slower chopped signal on 50 or 28MHz.

Under the best of conditions on 144MHz ssb is just intelligible, and narrow-band fm has been used successfully over other te circuits. Yet, under poor conditions the spread and flutter is so wide and rapid that no beat note can be obtained with the received signal, which appears merely as a change in the background noise.

In 1960 the authors claimed to have isolated three distinct modes of propagation classified by time delays and fading patterns. These were two-hop F-layer (which in 1958, with sunspot numbers in the region of 200, was quite common during the day), F-type te, and pure te (see Table 1). Whether or not they were right to separate F-type te and pure te into separate modes is debatable. The difference in time delay was small and not significant in terms of the probability of error in the system of measurement. However, if the classification is made on the basis of signal strength and fading pattern, then the division is apparently an obvious one.

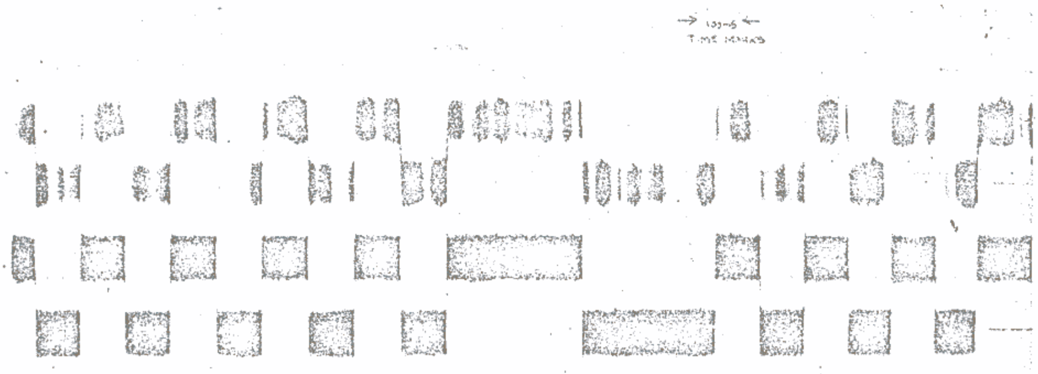


Fig 8. The letters 5B of 5B4CY as received by ZS6PW at 1845gmt on 30 January 1979 simultaneously on 50·498 and 28·220MHz. Note that the 50MHz pulse is 2ms behind the 28MHz pulse, which is a function of the keyer

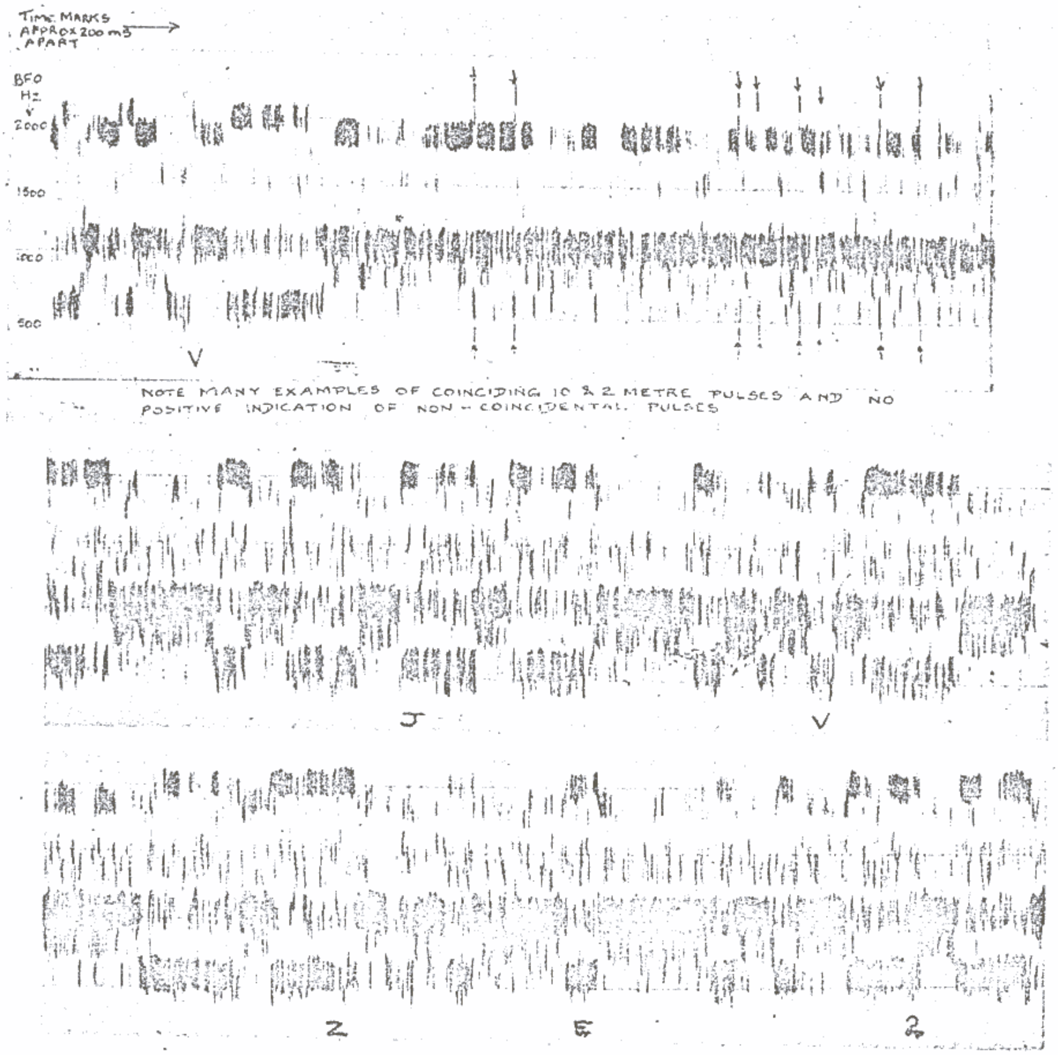
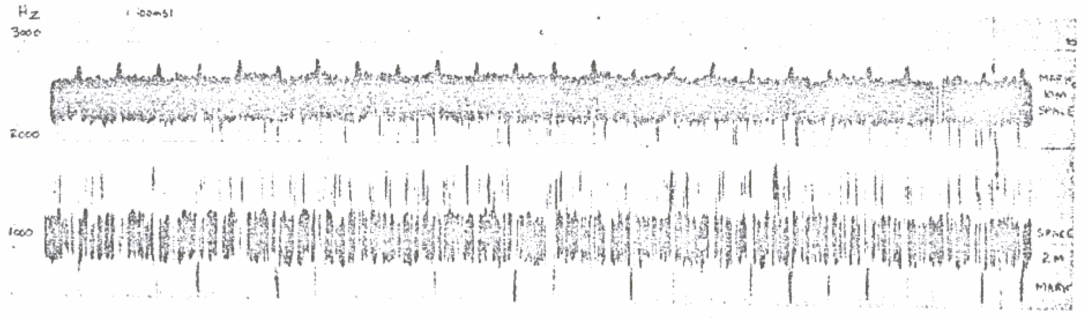


Fig 9. (a) (top) ZE2JV recorded by SV1AB at 1805gmt on 2 February 1979 from simultaneous 144 and 28MHz transmissions. (b) (below) ZE2JV pulsing recorded by SV1AB from simultaneous 144 and 28MHz transmissions on 2 February 1979



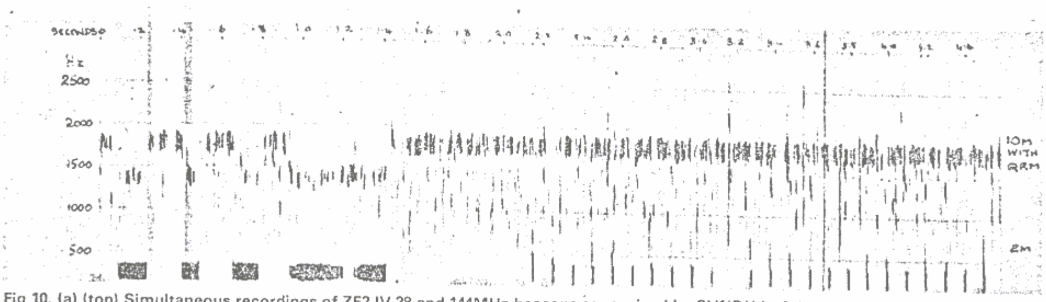
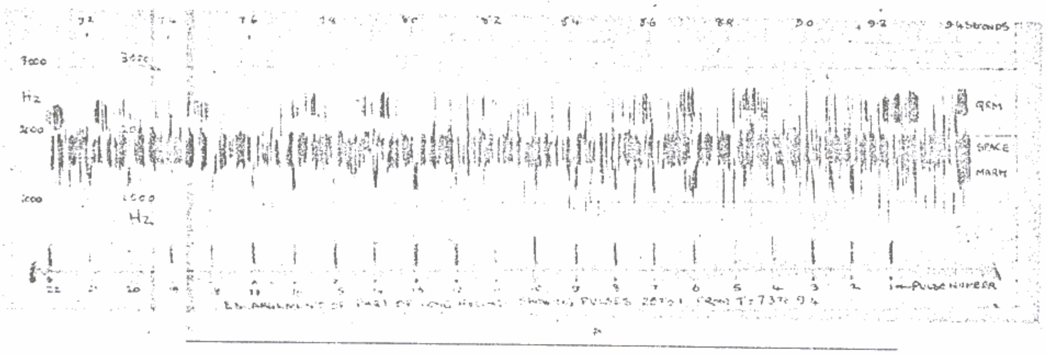


Fig 10. (a) (top) Simultaneous recordings of ZE2JV 28 and 144MHz beacons as received by SV1IDH in Athens at 1755gmt on 13 February 1979. (b) (below) Enlargement of part of the recording showing coinciding pulses on 28 and 144MHz



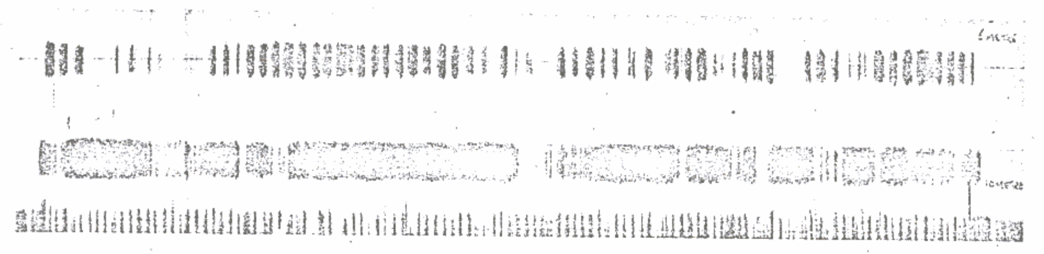


Fig 11. Simultaneous reception of plain carriers from 5B4CY by ZS6PW

F-type te signals are characterized by very strong signal strengths and the absence of flutter fading. Evidently a degree of focussing takes place, since received signals exceeding the free space value by up to 3dB were measured on several occasions on 28 and 50MHz. Such signals are common in the afternoon and early evening, cause considerable interference on Band 2, 3 and 4 CCIR television channels, as well as being responsible for the relatively common reception of African tv signals across Europe and their very strong reception in the Mediterranean area. The authors have not yet experienced this type of signal on 144MHz (possibly due to the southern African magnetic anomaly) but reports suggest that they might occur elsewhere [4].

Pure te signals are the type being received on 144 and 432MHz and are characterized by weak, diffuse and sometimes incoherent signals with flutter fading and frequency spreading in varying degrees of severity. Propagation on 28 and 50MHz may persist right through the night, and is usually, although not necessarily, confined to the hours of darkness. In the 1948 BERU Contest ZE2JV found that he could work British stations on 28MHz right around the clock, and in 1958 G2DX was worked on 50MHz on several occasions at noon with typical pure te signals. Early morning tep was frequently observed at 48MHz in the ZE2TEP experiment [2], 5B4CY has been heard on 50 and on 144MHz in Salisbury at 0600gmt, and ZS6DN on 144MHz has been heard in Athens at the same time in the morning.

The classification is therefore a useful one, but experience has shown that there are many shades between those signals, and signals that could not be classified as one or the other are often received, particularly on 144MHz.

*TO BE CONCLUDED NEXT MONTH*