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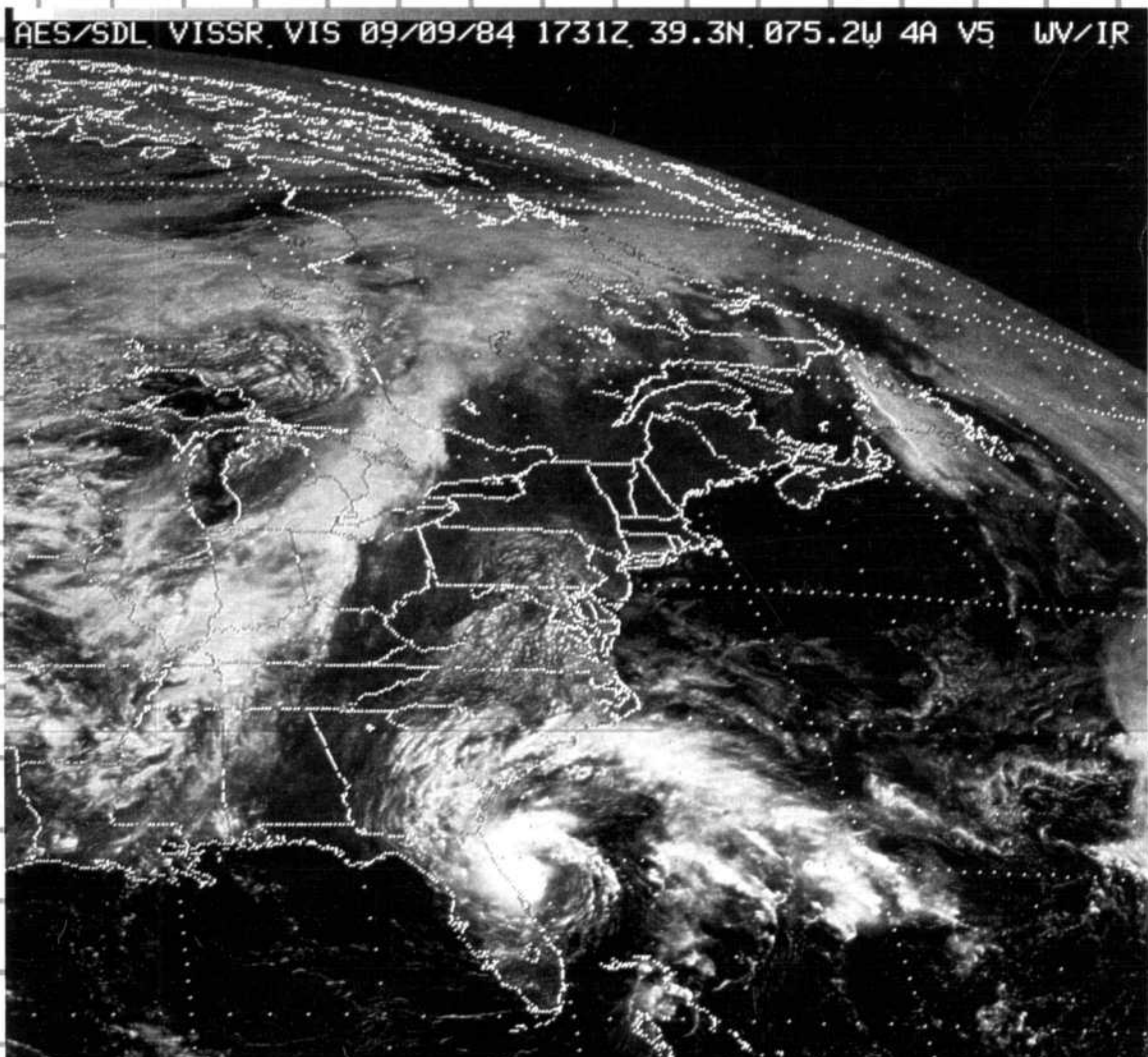
MARCH 1986

The ARRL Experimenter's Exchange



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ABOUT THE COVER

Hurricane Diana is shown off the coast of Florida in this satellite photo taken during the VHF QSO Party during September 1984.

THE AMERICAN RADIO RELAY LEAGUE, INC

The American Radio Relay League, Inc., is a noncommercial association of radio amateurs, organized for the promotion of interest in Amateur Radio communication and experimentation, for the establishment of networks to provide communications in the event of disasters or other emergencies, for the advancement of the radio art and of the public welfare, for the representation of the radio amateur in legislative matters, and for the maintenance of fraternalism and a high standard of conduct.

ARRL is an incorporated association without capital stock chartered under the laws of the State of Connecticut, and is an exempt organization under Section 501(c)(3) of the Internal Revenue Code of 1954. Its affairs are governed by a Board of Directors, whose voting members are elected every two years by the general membership. The officers are elected or appointed by the Directors. The League is noncommercial, and no one who could gain financially from the shaping of its affairs is eligible for membership on its Board.

"Of, by, and for the radio amateur," ARRL numbers within its ranks the vast majority of active amateurs in the nation and has a proud history of achievement as the standard-bearer in amateur affairs.

A bona fide interest in Amateur Radio is the only essential qualification of membership; an Amateur Radio license is not a prerequisite, although full voting membership is granted only to licensed amateurs in the US and Canada.

Purposes of *QEX*:

1) provide a medium for the exchange of ideas and information between Amateur Radio experimenters
2) document advanced techncial work in the Amateur Radio Field
3) support efforts to advance the state of the Amateur Radio art.

All correspondence concerning *QEX* should be addressed to the American Radio Relay League, 225 Main Street, Newington, CT USA 06111. Envelopes containing manuscripts and correspondence for publication in *QEX* should be marked: Editor, *QEX*.

Both theoretical and practical technical articles are welcomed. Manuscripts should be typed and double spaced. Please use the standard ARRL abbreviations found in the 1985 and 1986 ARRL Handbooks and in the January 1984 issue of *QST*. Photos should be glossy, black-and-white positive prints of good definition and contrast, and should be the same size or larger than the size that is to appear in *QEX*.

Any opinions expressed in *QEX* are those of the authors, not necessarily those of the editor or the League. While we attempt to ensure that all articles are technically valid, authors are expected to defend their own material. Products mentioned in the text are included for your information; no endorsement is implied. The information is believed to be correct, but readers are cautioned to verify availability of the product before sending money to the vendor.

Empirically Speaking. . .

The Metamorphosis

No, your eyes aren't deceiving you. This is the new *QEX.* You can readily see the improved eye appeal of typeset text, professionally rendered graphics, and a touch of color on the front cover in addition to your basic black ink.

Also, with this issue we are including display advertising, which helps in several different ways. You—the reader—can benefit from seeing current offerings of products of interest to experimenters. *QEX* provides the advertiser with a cost-effective medium for reaching the experimenter. The net income generated by advertising offsets the costs of *QEX*'s new look and keeps the subscription rate down in the noise level.

We're encouraging your local radio stores and other dealers to carry *QEX* in order to reach more experimenters.

In addition to the facelift, we've taken some steps to upgrade the editorial content with new specialized columns. In this issue, we are introducing a new regular column titled ">50" by Bill Olson, W3HQT. First licensed in 1958 with the call sign K1JDY, Bill has been active primarily on VHF since 1959. He now holds an Extra class license and is well known to the amateur VHF/UHF community. In 1968 he earned a BSEE from Swarthmore College, Pennsylvania. He worked as an applications engineer and microwave transistor project leader with Thomson-CSF Semiconductors. He was also employed at International Microwave Devices, Somerville, NJ as an applications engineer and microwave-amplifier design engineer. He is currently retired and living in central Maine. Bill's ham radio interests include VHF contests, home-brewing VHF and solid-state equipment, and antennas. He is a member of the Mt Airy (PA) VHF Society—better known as the Pack Rats. He participated in the W3CCX earth-moon-earth (EME) effort on 432 MHz and the HK1TL EME DX-pedition to Colombia, South America. While he is active on all bands from 80 meters through 13 cm, his main interest is in weak-signal work at 70 cm and above and weak-signal modes, meteor scatter, aurora and EME on all the VHF bands.

We're not stopping here. Look for announcements for new columns in subsequent issues of *QEX*.

The *QEX* editorial staff remains the same as before, ie, Paul Rinaldo, W4RI, as Editor and Maureen Thompson, KA1DYZ, as Assistant Editor. But this gets it only to the edited manuscript stage. That's where other HQ staffers take over. Ads are managed by Advertising Manager Lee Aurick, W1SE, and Deputy Advertising Manager Sandy Gerli, AC1Y. Michelle Chrisjohn, WB1ENT, is responsible for typesetting and layout. Sue Fagan and David Pingree will handle graphics. Lisa Fuini enters *QEX* subscriptions in the Circulation Department.

Pass the word: *QEX* is an information resource that experimenters can't afford to be without. —W4RI

Correspondence

Remembering the Carbon Composition Resistor

The interesting comments and evaluations of carbon composition (cc) resistors appearing in *QEX* (issues 41, 44 and 45) opened a few doors in my memory. I'd like to add my few, but brief comments on the subject.

In the late 1940s or early 50s, some builders discovered that 1/2-W cc resistors often became noisy and caused a peculiar sounding distortion in audio amplifiers. No one who has ever gently moved a 1/2-W cc resistor in a low-level amplifier stage with an insulated tool can forget the "scrunch-scrunch" sounds coming from the loudspeaker! This was one test that could most appropriately be done with a loudspeaker on the output rather than with a load resistor and oscilloscope. The cure was always to replace the offending resistor with that of a higher wattage. A 1-watt cc resistor was better and a 2-watt cc resistor was best. Eventually, the highest quality audio amplifiers I designed and built used only 1- and 2-watt cc resistors.

On occasion, replacing one of these noisy 1/2-W cc resistors with a higher wattage one would also clear hard-to-find cases of distortion that only appeared at the high power levels. It makes me wonder how many hundreds, or thousands, of homemade projects fell below the builder's expectations because of undetected problems like this. Let's hope that this focus on cc resistors will enable us to find and identify resistor types that are both stable and low noise from dc up through and beyond the VHF range. *—Harold Balyoz, W6YBP, PO Box 1972, Flagstaff, AZ 86002.*

Port of Call

I own an Osborne 1 computer and would like to operate a RTTY program. The computer has all the upgrades, but I'm having a problem trying to figure out how to access the output ports from BASIC or machine language. Any help on this matter would be appreciated.*—Robert L. Brewster, KL7LB, 514 Hemlock St, Kenai, AK 99611*

ACSSB Progress and VCR Interference

The ACSSB system is difficult to work with and I have been discouraged. However, Edward Larsen, KF6NX, and I have accomplished at least one important thing on 145.965 MHz—we have talked to each other!

KF6NX and I have our own unit and are starting tests on ACSSB. I have chosen 145.965 MHz because it is between AMSAT OSCAR-10 voice educational on 145.962 and voice bulletins. Furthermore, if the crystal oscillator circuit suggested by Dick Jansson, WD4FAB, (issue 40) is used, the frequency can be "rubbered" between these two probable ACSSB frequencies and AMSAT CALLING on 145.957 MHz. One of these two is probably what Riportella will be using when bulletins start on ACSSB (see Project Linkup, page 6, this issue.)

There are two items that can deceive an experimenter. One is that the pilot tone appears as ordinary AM to a casual listener. The second is that when users make the terrestrial ACSSB test, it is a known fact that OSCAR 10 is not in view.

So far, I have the feeling that the old SSB system used by AT&T with the carrier suppressed 12 dB is far simpler and can be phase locked. I cannot help but wonder if all the ACSSB complexity is used to: 1) allow effective squelch; and 2) allow phase modulation of the pilot tone to create CTCSS subaudible tones. I admit that I do not know if AGC information at a 25-Hz rate can be received off a carrier phase lock, but it seems possible. Fig 1 shows the original TXCO circuit. You can see that the original goal mentioned can be easily accomplished.

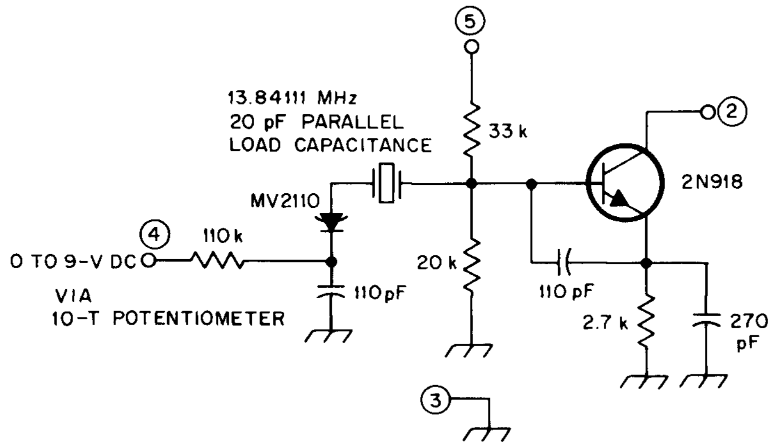

Fig 1—The original ACSSB TXCO circuit covers 145.960 to 145.976 MHz.

On the subject of VCRs and interference: Approximately one third of the American households operate TV recorders. Hams now have a problem similar to that experienced in the fifties. The VCR is extrasensitive to fields generated by amateur equipment. Equally annoying is the QRM these recorders generate to high-frequency receivers. Therefore, early on, can we find solutions and suggestions similar to those of the external antenna TVI years?

It is vital that the manufacturers of video recording equipment both foreign and domestic be implored to include inexpensive high-pass filters and line-isolation design before we repeat the distasteful experience of earlier years. Do any readers have experience to offer when it is apparent that 80-m signals are entering the video circuits directly and all filtering that can be done is in place?*—Cliff Buttschardt, W6HDO, 950 Pacific St, Morro Bay, CA 93442.*

Project Linkup: A Program Synopsis

By Vern "Rip" Riportella, WA2LQQ
AMSAT President
PO Box 177
Warwick, NY 10990

One of the hallmarks of a mature facility is the capacity of that facility to be used by all; not just by those with special training. When it attains this maturity, a facility becomes a "utility." Thereafter, it forms an indispensable foundation resource to the community it serves.

As OSCAR satellites enter their 25th year, AMSAT is planning several experiments which will demonstrate the potential of existing and future satellites for general purpose, utility use by the Amateur Radio community at large. For two and a half decades OSCARs have been perceived as difficult-to-use novelties off the beaten path of general ham communications. These perceptions will change dramatically during 1986 when Project Linkup gets under way.

Beginning in the spring of 1986, Project Linkup will commence a series of demonstrations and experiments. These will be designed to elicit new engineering data on amateur satellite communications. Further, they will inform the general Amateur Radio community on imminent breakthroughs in the manner in which amateur satellite communications services are provided and used. This synopsis describes, in general terms, the plans for Project Linkup. More specific details with schedules and modes of operation, frequencies, etc, will be published soon.

Objectives of Project Linkup include:

- Demonstration of direct bulletin reception via AMSAT OSCAR 10 to the user using minimal 70-cm receive equipment.
- Demonstration of indirect bulletin reception via AMSAT OSCAR 10 to the user through the intermediary of a local gateway repeater.
- Comparison of NBFM and ACSSB emissions for intelligibility under variable, real-world conditions.
- Promotion of spectrum-efficient emission modes such as ACSSB.
- Provision of current AMSAT and satellite operating information to areas not presently covered.
- Development of space and satellite interest through exposure of capabilities in a productive, accessible format.
- Demonstration of concept and stage-setting for improved Phase 3 (Molniya) and Phase 4 (geosynchronous) satellites.
- Establishing an experimental basis and framework for direct satellite to vehicle transmissions.

The primary test vehicle for Project Linkup will be AMSAT OSCAR 10, Mode L. Mode L has an uplink band at 1269 MHz and a downlink band at 436 MHz. Stations participating in Linkup will require only a modest 436-MHz receive system. Alternatively, if a Mode-L gateway station is in range, access to Linkup will require as little as a 2-meter handheld and rubber duck!

For direct FM reception on 436 MHz, initial experiments suggest a minimum antenna gain of 12 to 13 dBi, 18-dB gain from a GaAsFET preamp with a noise figure not higher than 0.8 dB at 436 MHz and a modern 70-cm FM receiver tuned to 436 MHz will be required. A very small portable receive only (RO) is quite feasible. As an alternative, a 70-cm to 2-meter receive converter can be used to feed a 2-m handheld. The general use of 2-m handhelds makes this alternative easily accessible by many with minimal equipment including the apartment dweller. Imagine... being linked to an intercontinental satellite with just your handheld!

For the SSB portion of the demonstration, a standard Mode-L receive station might consist of a 70-cm antenna in the 12 to 13 dBi range, a GaAsFET preamp and a 70-cm all-mode receiver. As an alternative, a 70-cm to 10-m receive converter might be substituted to allow use of an HF rig to receive the SSB signals. Special Amplitude Companding (AC) techniques will be applied to the SSB signals. The resultant ACSSB signals will yield improved reception for stations equipped with suitable equipment, yet the ACSSB signals will be fully compatible with normal SSB receive equipment.

Project Linkup will demonstrate the concept of hemispheric bulletin distribution for general use. As such it will set the stage for both near-future and long-term experiments. Late in 1986, Phase 3C will be launched. It will carry a new Mode-L transponder with improved sensitivity for better overall performance. In addition, a new Mode-S transponder will be introduced. Designed primarily for FM, Mode S will use 70 cm up and 13 cm (2401 MHz) down. Mode S and Mode L on Phase 3C both will open the doors of advanced UHF satellite communications to many amateurs. Moreover, these modes may set the groundwork for still more advanced modes on Phase 3D and Phase 4 in a few years.

Your participation in these experiments as part of Project Linkup is cordially invited. Being part of the future of Amateur Radio today is one of the attractions to being an AMSAT member and being part of the high ground embodied in the concept of Project Linkup. Find out about it today. Write: Project Linkup, c/o AMSAT, PO Box 27, Washington, DC 20044. An SASE is required.

Bits

Ad Astra

What is an *Ad Astra*? Why, the Journal of the Atari Microcomputer Network, of course. If you own an Atari computer, you might be interested in this bi-monthly publication. Averaging about 20 pages, information regarding applications, programming and operation of the Atari microcomputer system appears in print. The Net is a nonprofit organization made up of Amateur Radio operators, short-wave listeners and Atari computer enthusiasts who share a common interest. It meets every Sunday at 1600Z on 14.325 MHz.

Want more information? Contact Net Coordinator Dave Byrd, KD7VA, or the Ad Astra Editor Gil Frederick, VE4AG, 130 Maureen St, Winnipeg, Manitoba, Canada, R3K 1M2.

Predicting Tropo Openings Using Meteorological Parameters

By Richard Miller, VE3CIE
RR1, Hillsburgh, Ontario
CANADA N0B 1Z0

The VHF QSO Party of September 8-9, 1984 was a memorable event. A tropospheric duct had formed along the eastern US seaboard providing contacts from Nova Scotia to Florida. Considered to be one of the best tropo openings of the last decade, the scene was set by the combination of a large high pressure system (Figs 1, 2) off the mid-Atlantic states and Hurricane Diana off the coast of Florida. The resulting tropo duct produced conditions which lead to record scores.

This article will examine the radio meteorological conditions that produced the duct. We will use the potential radio refractive index as described by K. H. Jehn, and an analysis method developed by R. G. Flavell, G3LTP.[1,2] In addition, a radio meteorological index that can be used by amateurs to determine the occurrence of tropo ducting conditions associated with subsidence (the sinking of air in the atmosphere) inversions will be suggested.

Subsidence Inversions and the Formation of Radio Ducts

In an earlier work by E. Pocock, W3EP, the process of subsidence associated with high pressure systems and the formation of radio ducts were recounted.[3] Subsidence sometimes produces a layer in the atmosphere in which temperature increases, but moisture (water vapor) decreases with height. If the lapse rates of temperature and moisture are sufficient, a radio duct forms. By calculating the change in radio refractivity (N) across the layer, the amount of refraction can be determined by:

$$N = \frac{77.6}{T}\left(p + 4810\,\frac{e}{T}\right) \qquad \text{(Eq 1)}$$

where
- N = the radio refractivity
- p = atmospheric pressure in millibars (mb)
- e = partial water vapor pressure in mb
- T = temperature in Kelvins (T °C + 273)

In an earlier article I wrote for *QST*, I described various modes of tropospheric propagation that occur because of refraction.[4] I also indicated that a decrease in refractivity of −157 N units per 621 miles is required for the formation of a radio duct. Pocock also noted that the inversion depth (i.e., duct width), determines the minimum frequency that is refracted. The relationship between duct width and frequency of the refracted signal (Kerr) is illustrated in Fig 3.[5] The cutoff frequency for ducting does not sharply divide regions of propagation

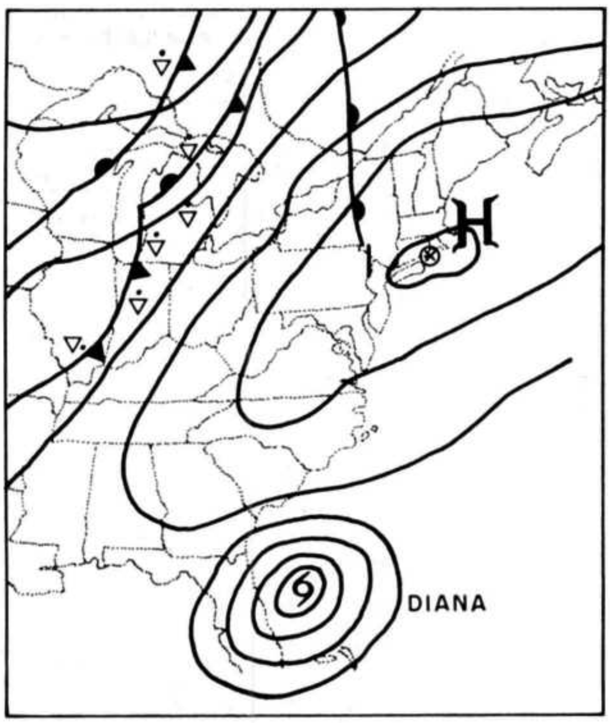

Fig 1—A large pressure system off the east coast of the US is shown in this surface weather map taken at 091200 UTC during the VHF QSO Party September 1984.

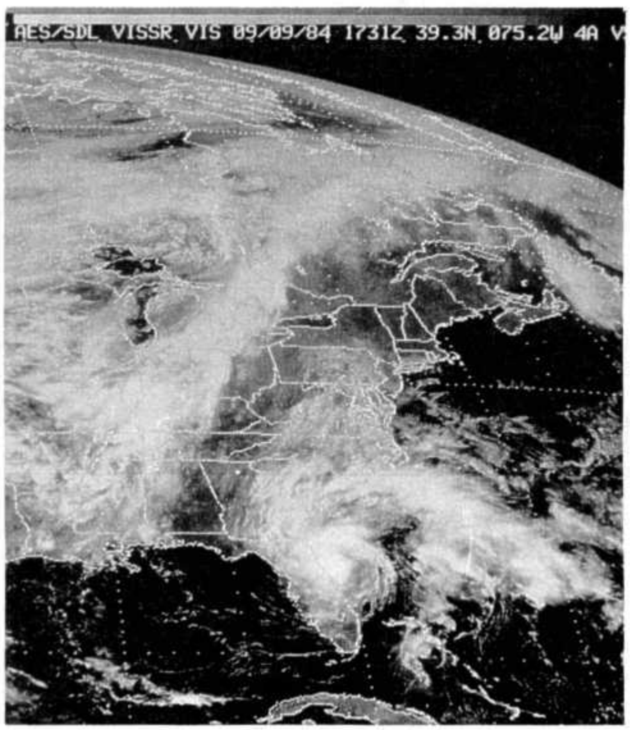

Fig 2—This satellite photo taken during the VHF QSO Party of September 1984 shows Hurricane Diana off the Florida coast. Time of photo is 091730 UTC.

from nonpropagation, and signals several times the cut-off wavelength may be affected.

For the amateur bands, the duct width ranges from about 1,082 feet at 50 MHz to 164 feet at 903 MHz. Because of the relatively narrow duct widths, it is necessary to calculate the refractive index as closely spaced intervals to determine the existence of the radio duct. Jehn described the potential radio refractive index K as:

$$K = \frac{(1000)^{0.714}}{p} N \qquad \text{(Eq 2)}$$

This eliminates the variation of N with respect to pressure. As a result, it emphasizes the changes in N caused by temperature and moisture variation across the radio duct. Flavell used the K index in space and time profiles to analyze the areal extent and time of occurrence of ducting conditions. (A complete description of Flavell's method can be found in the *RSGB VHF-UHF Manual.)*

Ducting Conditions During the September 1984 VHF QSO Party

Gary W. Capson, VE1AHM, grid square FN76 in New Brunswick, reported an opening to the Carolinas, a distance of about 990 miles. Note that over such distances the bulge in the earth is about 31.05 miles. It is apparent that any reasonable antenna height will have little effect on light-of-sight communication. What is required? A condition in which the signal is bent along the curvature of the earth rather than one propagated in a straight line. A radio duct, if present, may provide these conditions.

Another way to consider the situation is if the bulge in the earth were flattened, line-of-sight communication could be achieved. Fig 4 illustrates the theoretical earth flattening for various radio refractivity lapse rates. Fig 5 assumes 49-foot high antennas are positioned at both ends of the radio link and a smooth earth profile exists. Possible communication distances for various lapse rates are also illustrated. Note that true DX conditions (distances greater than 490 miles as defined by Pocock), occur only when ducting is present.

Analysis of the September 1984 Data

By Tuesday, September 4, 1984 a large high pressure center had formed over the Saskatchewan-Manitoba

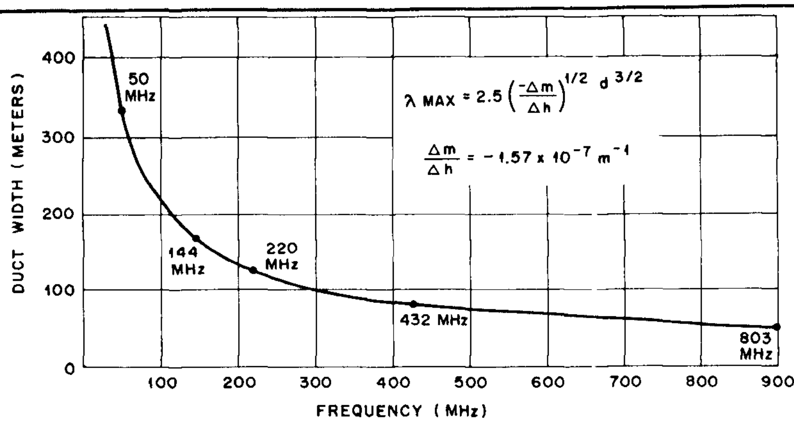

Fig 3—Tropospheric duct width vs frequency.

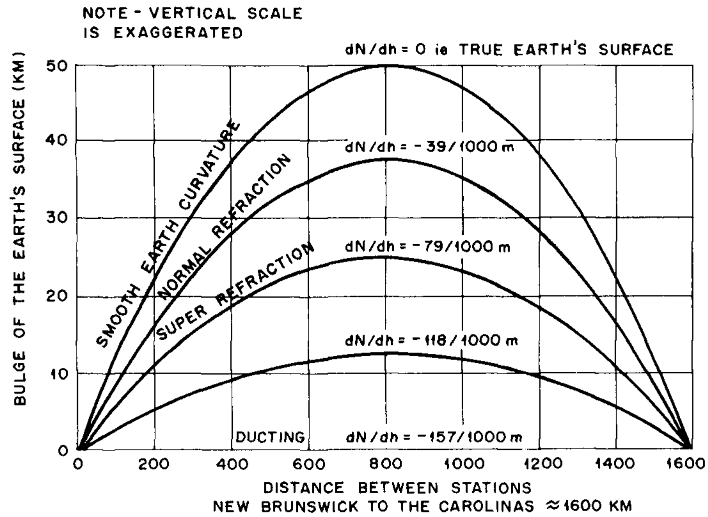

Fig 4—A variation in the radio refractive index would cause a theoretical flattening of the earth.

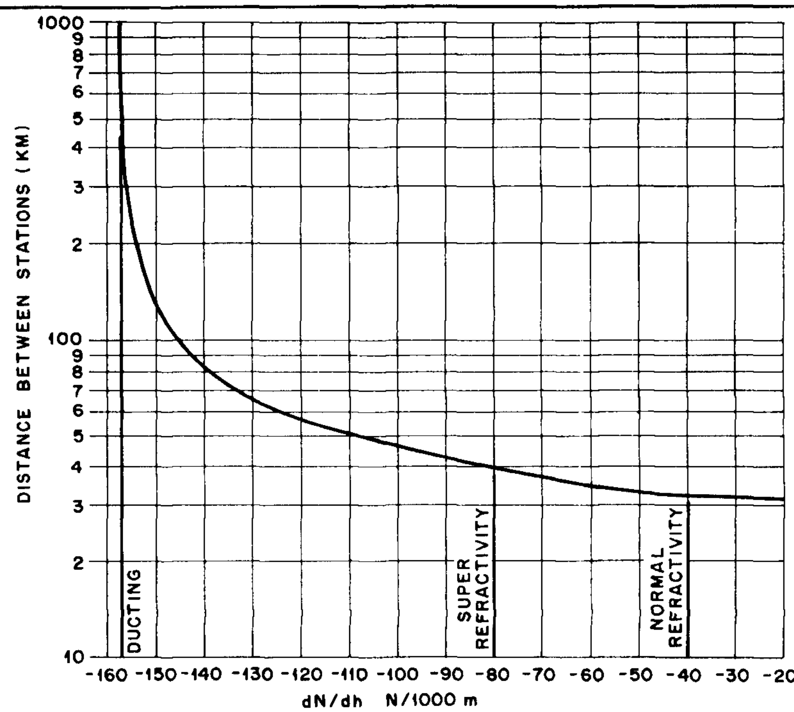

Fig 5—Possible communication distance between stations vs refractivity lapse rate. This graph displays an assumption that the antenna height is 49 feet, over a smooth earth, where $D = \sqrt{51\ Kh}$ (K = the potential radio refractive index and h = the antenna height).

border in Canada. As the week progressed, the pressure center drifted slowly across the continent (Fig 6) until Friday, September 7 when it reached the Atlantic seaboard. Throughout the 8th and 9th, the center's progress was slowed by tropical storm Diana. The high pressure system lay along the coast providing a radio duct and some of the best VHF contest DX ever.

We will use the space and time profiles of potential refractive index as suggested by Flavell to examine the development of the radio duct. In order to produce the space and time profiles of potential radio refractivity K, the distribution of temperature, water vapor and pressure in the atmosphere must be known. These data were obtained from radiosonde flights made at several locations from Maine to Florida. The locations of these stations are given in Fig 7.

A short program written for a VIC 20® computer was used to calculate values of K from the raw data. The results were then plotted as time profiles for each radiosonde station and space profiles for stations along the high pressure ridge. The results of this analysis are presented in Figs 8 to 13 for the time profiles, and Figs 14 and 15 for the space profiles.

In Fig 9, the Albany time profile shows the variation of K plotted against pressure and time. The time profile extends from September 6 to 11. The feature to note in this profile is the tight gradient of equal potential refractivity lines which begins on Saturday, September 8, and continues until Monday, September 10 between 800 and 900 mb. This feature is characteristic of tropospheric ducting in that the steep lapse rate of refractivity required for ducting is indicated by the tight gradient. Note that the tightest and lowest gradient occurs during the contest period when propagation conditions were best. Examination of the other time profiles reveals a similar feature although, at the more southerly locations, the feature tends to be higher. Examination of the space profiles for stations from north to south for 090000 UTC, Saturday evening (Fig 14), and 091200 UTC, Sunday morning (Fig 15), reveal the tight gradient feature extending over the area of enhanced propagation. Note the variation in height of the feature from between 850 and 900 mb at the northern stations to between 800 and 750 mb at the southern stations. Through these space and time profiles, the areal extent and onset of the ducting condition has been explained.

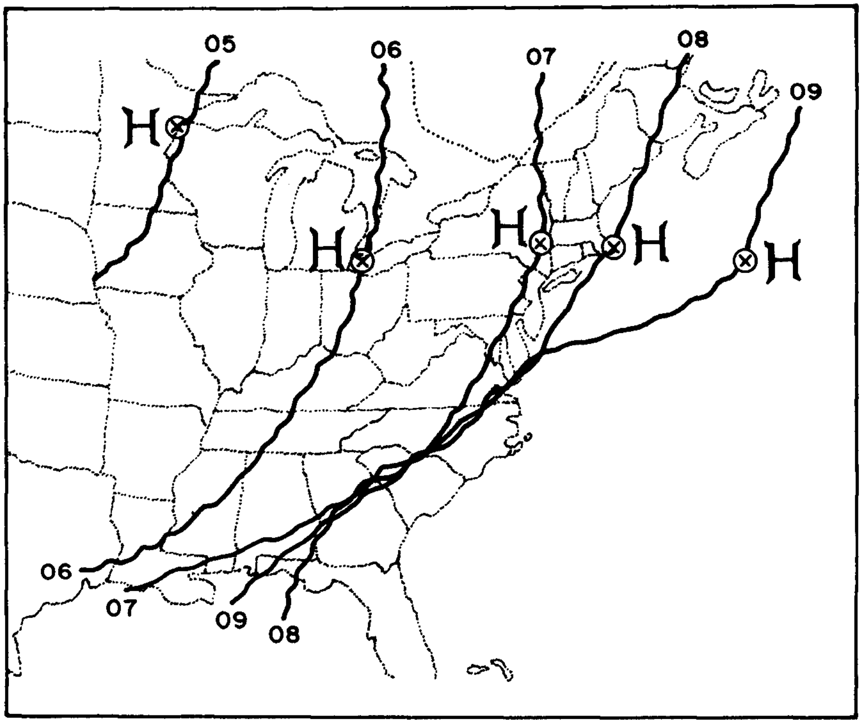

Fig 6—The movement of a high pressure ridge over the Saskatchewan-Manitoba border on September 5-9, 1984.

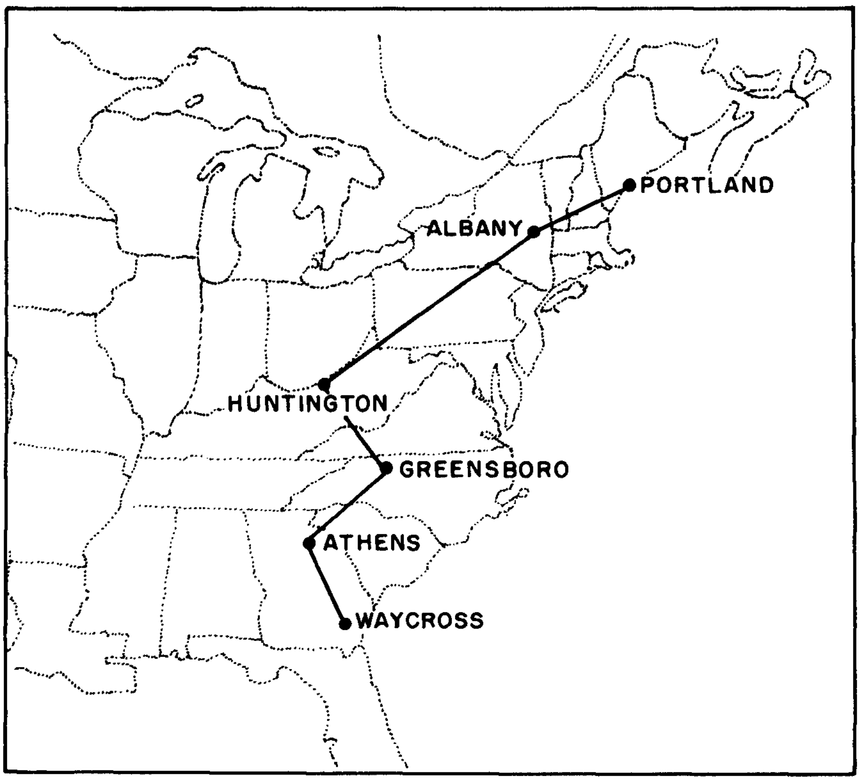

Fig 7—The locations of the upper air radiosonde stations used for data analysis for the VHF contest (the path shown for space profiles is for Figs 14 and 15).

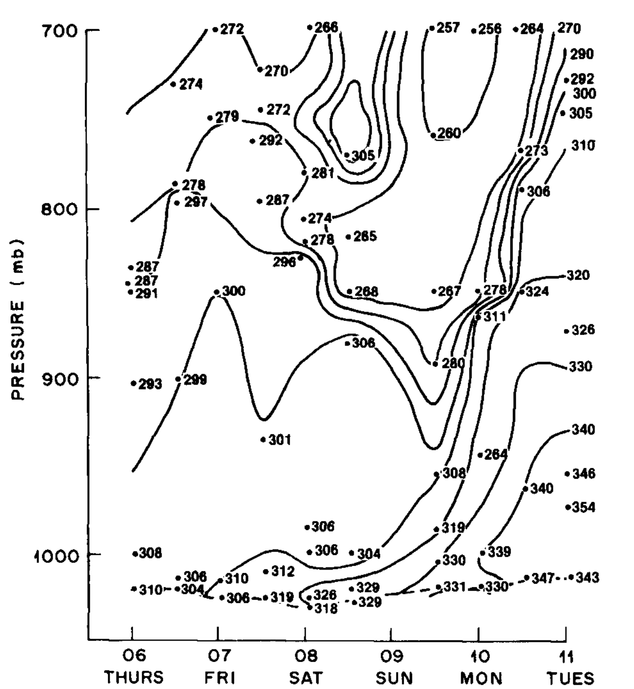

Fig 8—A potential radio refractivity time profile for Portland, MA, 1984 September VHF contest.

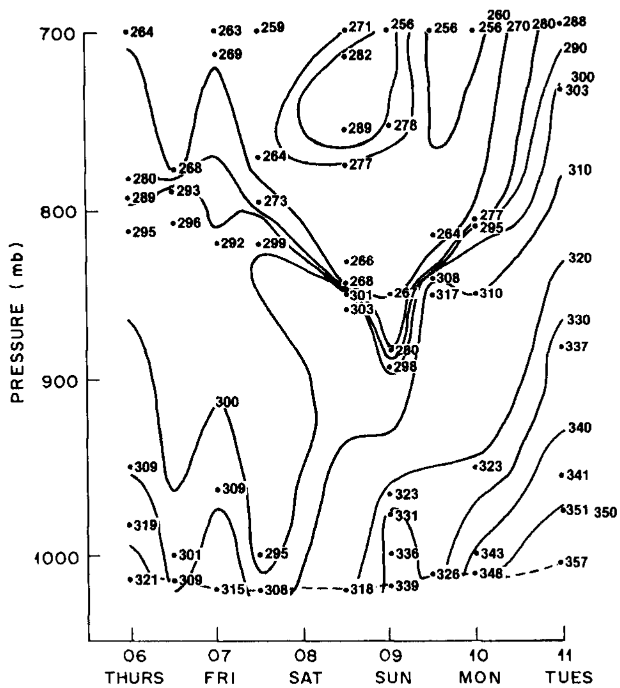

Fig 9—A potential radio refractivity time profile for Albany, NY, 1984 September VHF contest.

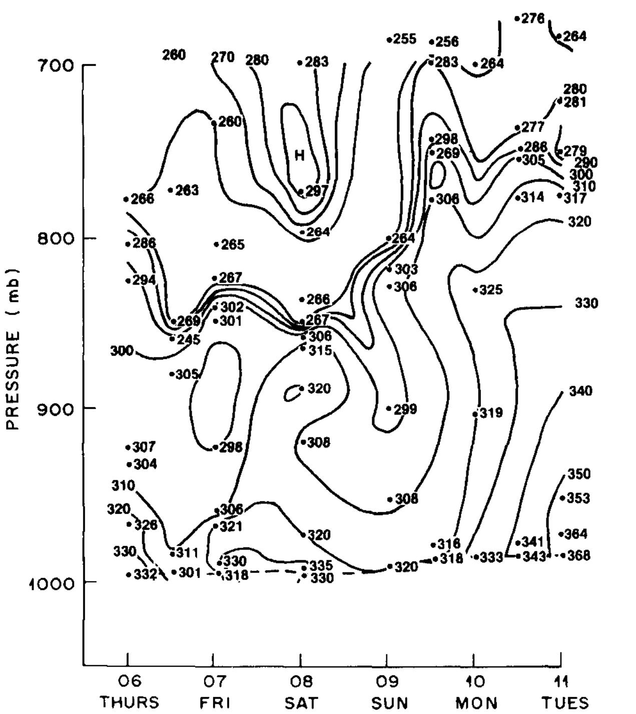

Fig 10—A potential radio refractivity time profile for Huntington, WV, 1984 September VHF contest.

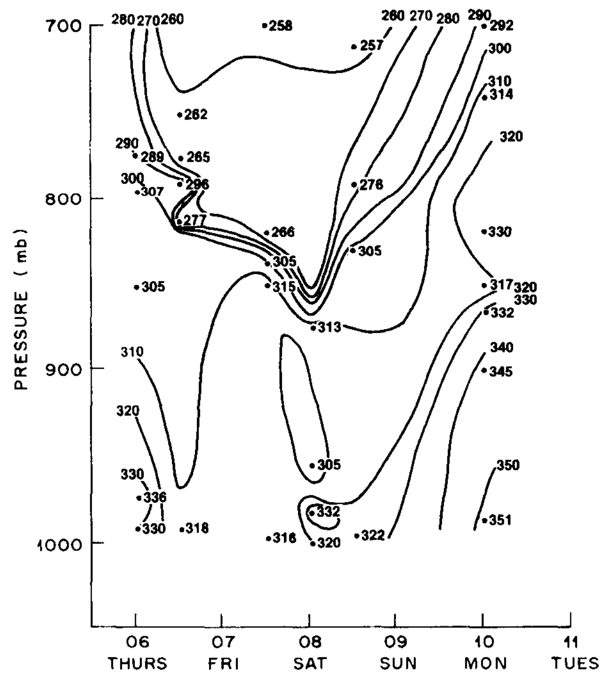

Fig 11—A potential radio refractivity time profile for Greensboro, NC, 1984 September VHF contest.

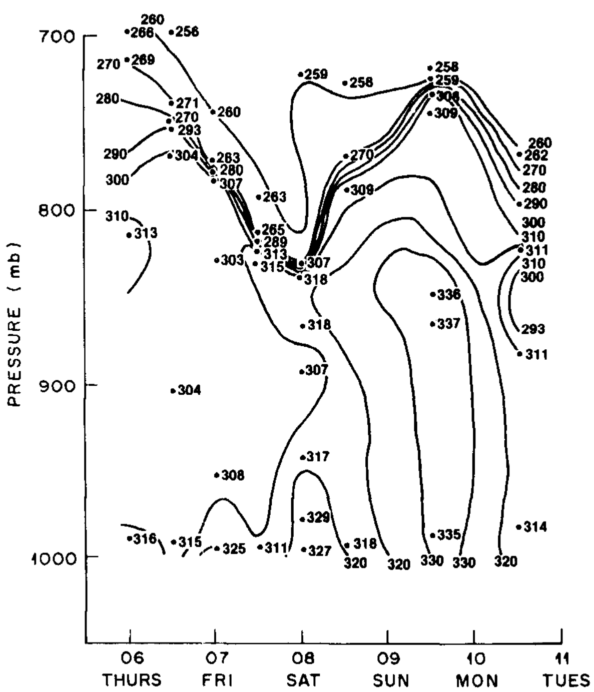

Fig 12—A potential radio refractivity time profile for Athens, GA, 1984 September VHF contest.

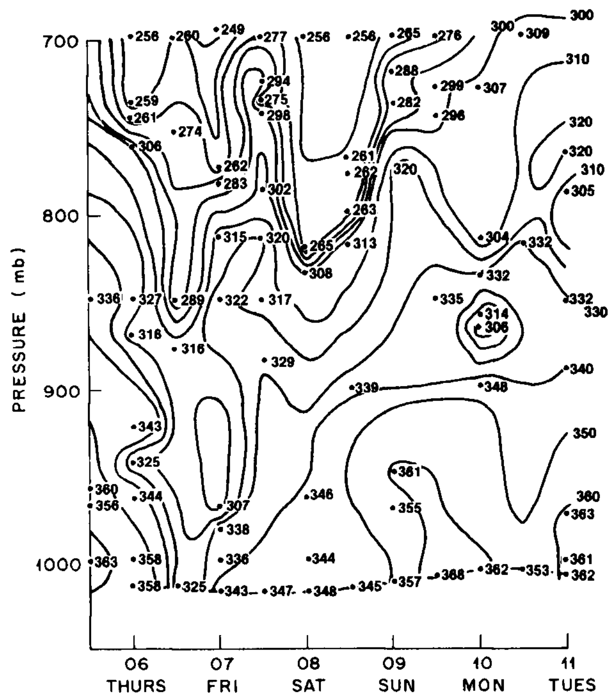

Fig 13—A potential radio refractivity time profile for Waycross, GA, 1984 September VHF contest.

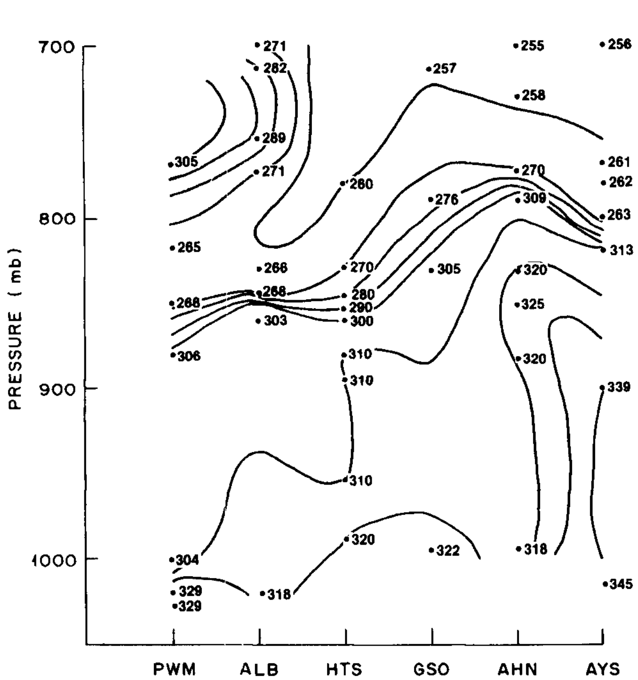

Fig 14—A potential radio refractivity space profile from Portland, MA to Waycross, GA, 1984 September VHF contest, September VHF contest, September 9, 0000 UTC.

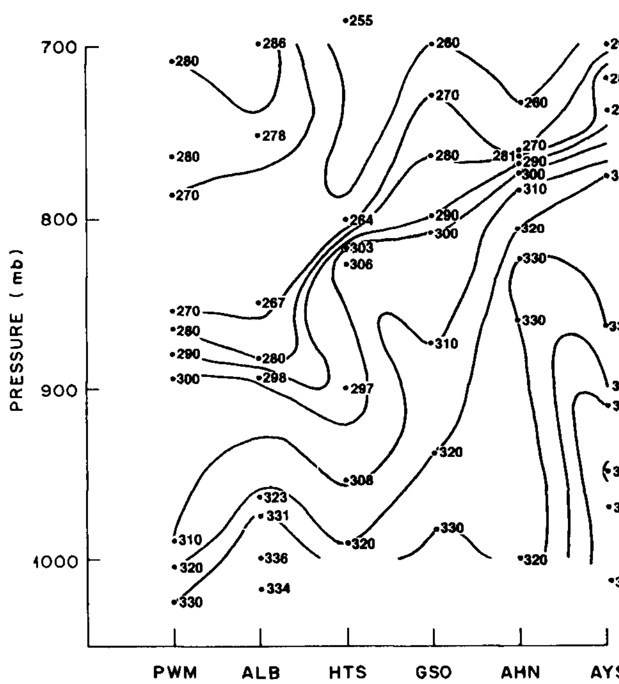

Fig 15—A potential radio refractivity space profile from Portland, MA to Waycross, GA, 1984 September VHF contest, September 9, 1200 UTC.

A Radio Meteorological Index for Amateur Use

As is evident from the previous discussion, a considerable amount of meteorological data must be acquired and processed in order to produce the space and time profiles of potential radio refractivity. Generally, most amateurs do not have access to such quantities of data nor do they have the time necessary to produce such analyses. Accordingly, a single radio meteorological index, requiring a minimum amount of data and calculation is proposed for amateur use. The purpose of this index would be to alert the user to conditions in which a tropospheric radio duct would form.

K_{850}—Tropospheric Refractivity Index

Data gathered at upper air radiosonde stations is recorded at pressure levels at which significant changes occur in the measured variables. Much data is also gathered at "mandatory levels" (Fig 16) in each flight—one of which is the 850 mb level. Examination of the various time profiles (Figs 8 to 13) reveals that the strong gradient indicative of ducting conditions usually passes through the 850 mb level during enhanced propagation conditions. If we plot the 850 mb value of the potential refractivity K_{850} vs time for each of the upper air stations, it is seen that a minimum occurs in the plotted values just prior to or during the enhanced propagation conditions of the contest. (Fig 17) K_{850} can be derived as follows:

$$K = \frac{(1000)^{0.714}}{p}N$$

$$K_{850} = \frac{(1000)^{0.714}}{850} \times \left(\frac{77.6}{T}\left(850 + 4810\frac{e}{T}\right)\right)$$

$$K_{850} = \frac{74073}{T}\left(1 + 5.659\frac{e}{T}\right) \quad \text{(Eq 3)}$$

where

T = temperature at 850 mb in degrees K

e = water vapor pressure at 850 mb in mb

An amateur wishing to monitor the K_{850} index should select the nearest upper air station to his or her QTH (Table 1), and obtain the necessary data on a daily basis. Data for calculating the index should be available from a local weather office. Amateurs participating in the NWS SKYWARN program should be able to easily obtain the data through their NWS contacts. The following raw data is required:

- the 850 mb temperature in °C = T_{850}
- the 850 mb dew point temperature in °C = Td_{850}

The T_{850} is converted to Kelvins by adding 273.

$$T_{850}\,K = T_{850}\,°C + 273$$

Their are several ways to convert the 850 mb dewpoint temperature to water vapor pressure in mb. One way is to use the data in Table 2 and a calculator. The K_{850} index of radio refractivity may also be determined from the graph in Fig 18 or the computer program in Table 3. Data is collected twice daily at upper air stations at 00 UTC and 1200 UTC, thus two values of K_{850} can be determined daily.

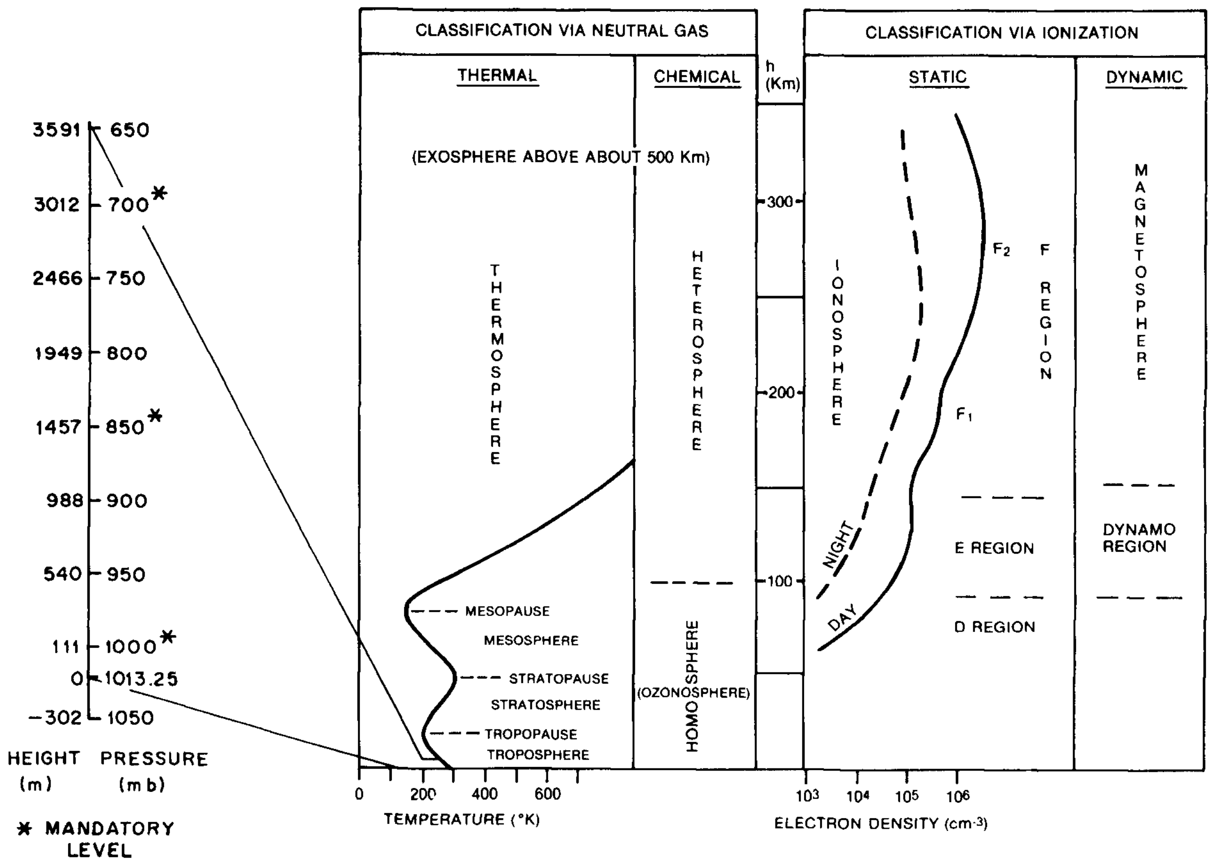

Fig 16—ICAO standard atmosphere. The chart to the right shows upper atmospheric nomenclature and the different ways of classifying the atmospheric structure. The information on the left denotes mandatory level data.

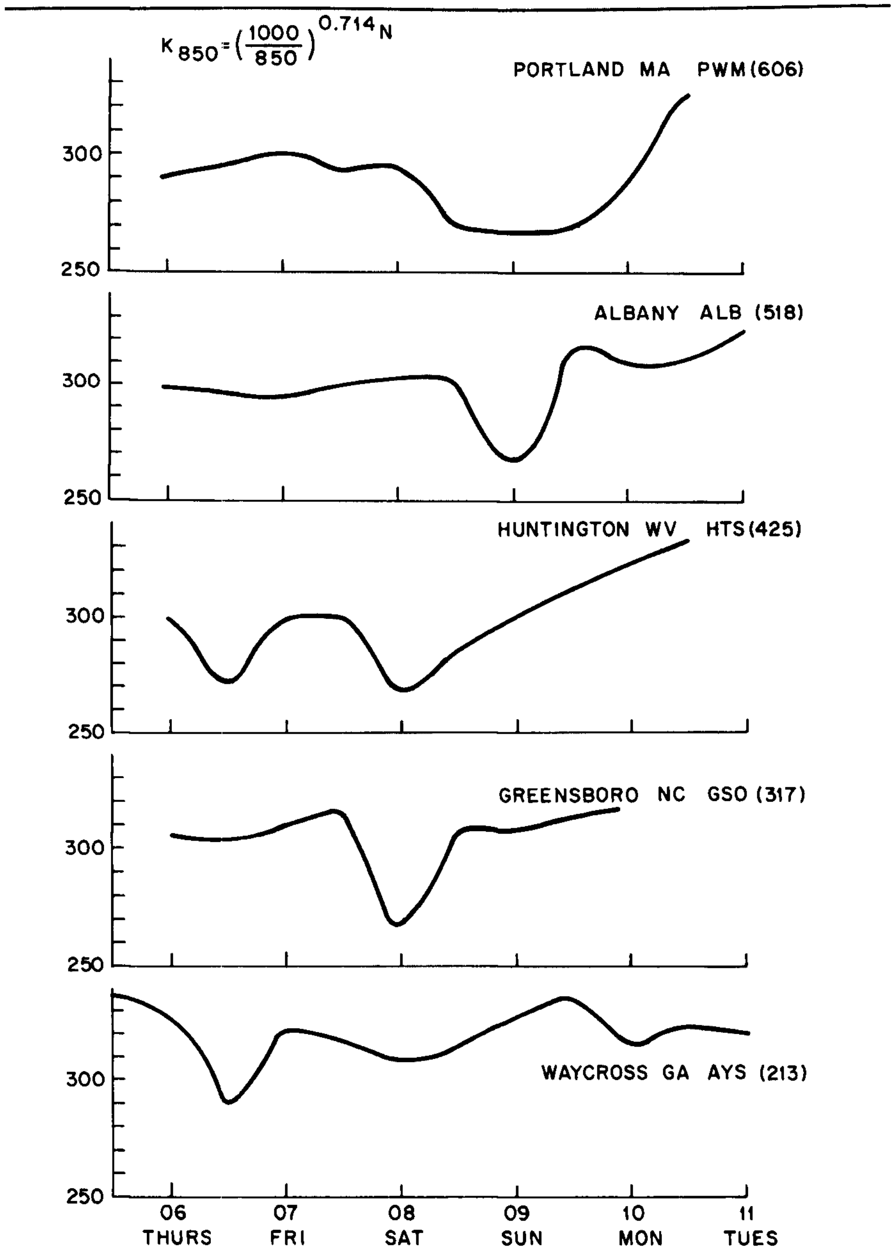

Fig 17 — The 850 mb potential refractivity for each location shown in Figs 8 to 15.

Table 1

Upper Air Radiosonde Stations

ID	*Station*
UIL	Quillayute, WA
GEG	Spokane, WA
SLE	Salem, OR
MFR	Medford, OR
OAK	Oakland, CA
VBG	Vandenberg, CA
MYF	San Diego, CA
BOI	Boise, ID
WMC	Winnemucca, NV
ELY	Ely, NV
UCC	Yucca Flat, NV
GTF	Great Falls, MT
GGW	Glasgow, MT
LND	Lander, WY
SLC	Salt Lake City, UT
INW	Winslow, AZ
TUS	Tucson, AZ
BIS	Bismarck, ND
RAP	Rapid City, ND
HON	Huron, SD
LBF	North Platte, NE
OMA	Omaha, NE
DDC	Dodge City, KS
TOP	Topeka, KS
GJT	Grand Junction, CO
DEN	Denver, CO
ABQ	Albuquerque, NM
OKC	Oklahoma City, OK
AMA	Amarillo, TX
ELP	El Paso, TX
MAF	Midland, TX
DRT	Del Rio, TX
SEP	Stephenville, TX
GGG	Longview, TX
BVE	Bootheville, LA
VCT	Victoria, TX
BRO	Brownsville, TX
INL	Intl Falls, MN
STC	St. Cloud, MN
UMN	Monett, MO
LIT	Little Rock, AR
LCH	Lake Charles, LA
BVE	Bootheville, LA
GRB	Green Bay, WI
PIA	Peoria, IL
SLO	Salem, IL
JAN	Jackson, MI
SSM	Sault Ste Marie, MI
FNT	Flint, MI
DAY	Dayton, OH
BNA	Nashville, TN
CKL	Centerville, AL
PWM	Portland, MA
ALB	Albany, NY
CHH	Chatham, MD
JFK	New York, NY
BUF	Buffalo, NY
PIT	Pittsburgh, PA
HTS	Huntington, WV
IAD	Washington, DC
WAL	Wallops, VA
GSO	Greensboro, NC
HAT	Cape Hatteras, NC
AHN	Athens, GA
AYS	Waycross, GA
CHS	Charleston, SC
TPA	Tampa, FL
MIA	Miami, FL
AQQ	Apalachicolla, FL
EYW	Key West, FL

Summary and Conclusions

The radio meteorological conditions that occurred during the September 1984 VHF QSO Party and produced an outstanding radio duct along the Atlantic coast from New Brunswick to Florida have been analyzed. This analysis was performed using time and space profiles of the potential radio refractive index. I've shown that a simplified K_{850} index can be used by amateurs to monitor the onset of tropospheric ducting conditions which are produced by high pressure systems and associated subsidence inversions. The source of the raw data required to calculate the K_{850} index has been indicated. As many amateurs as possible should monitor the K_{850} index to determine the extent of its usefulness. Also take note that in southern areas it appears that the strong refractivity gradient associated with ducting conditions may not always penetrate the 850 mb level. Perhaps, the K_{700} index would be more suitable to southern areas. This is a topic for future investigation.

Acknowledgement

I would like to acknowledge the contributions of The Atmospheric Environment Service, Environment Canada. They are responsible for supplying the meteorological data presented in this article.

Table 2—A chart of the dew point temperature and vapor pressure.

Dew Point

Temperature °C	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Metric units									
°C.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.
−50	0.06356									
−49	0.07124	0.07044	0.06964	0.06885	0.06807	0.06730	0.06654	0.06578	0.06503	0.06429
−48	0.07975	0.07886	0.07797	0.07710	0.07624	0.07538	0.07453	0.07370	0.07287	0.07205
−47	0.08918	0.08819	0.08722	0.08625	0.08530	0.08435	0.08341	0.08248	0.08156	0.08065
−46	0.09961	0.09852	0.09744	0.09637	0.09531	0.09426	0.09322	0.09220	0.09118	0.09017
−45	0.1111	0.1099	0.1087	0.1075	0.1063	0.1052	0.1041	0.1030	0.1018	0.1007
−44	0.1239	0.1226	0.1213	0.1200	0.1187	0.1174	0.1161	0.1149	0.1136	0.1123
−43	0.1379	0.1364	0.1350	0.1335	0.1321	0.1307	0.1293	0.1279	0.1266	0.1252
−42	0.1534	0.1518	0.1502	0.1486	0.1470	0.1455	0.1440	0.1424	0.1409	0.1394
−41	0.1704	0.1686	0.1669	0.1651	0.1634	0.1617	0.1600	0.1583	0.1567	0.1550
−40	0.1891	0.1872	0.1852	0.1833	0.1815	0.1796	0.1777	0.1759	0.1740	0.1722
−39	0.2097	0.2076	0.2054	0.2033	0.2013	0.1992	0.1971	0.1951	0.1931	0.1911
−38	0.2323	0.2299	0.2276	0.2253	0.2230	0.2207	0.2185	0.2162	0.2140	0.2119
−37	0.2571	0.2545	0.2520	0.2494	0.2469	0.2444	0.2419	0.2395	0.2371	0.2347
−36	0.2842	0.2814	0.2786	0.2758	0.2730	0.2703	0.2676	0.2649	0.2623	0.2597
−35	0.3139	0.3108	0.3077	0.3047	0.3017	0.2987	0.2957	0.2928	0.2899	0.2870
−34	0.3463	0.3429	0.3396	0.3362	0.3330	0.3297	0.3265	0.3233	0.3201	0.3170
−33	0.3818	0.3781	0.3745	0.3708	0.3673	0.3637	0.3602	0.3567	0.3532	0.3497
−32	0.4205	0.4165	0.4125	0.4085	0.4046	0.4007	0.3968	0.3930	0.3893	0.3855
−31	0.4628	0.4584	0.4541	0.4497	0.4454	0.4412	0.4370	0.4328	0.4287	0.4246
−30	0.5088	0.5040	0.4993	0.4946	0.4899	0.4853	0.4807	0.4762	0.4717	0.4672
−29	0.5589	0.5537	0.5485	0.5434	0.5383	0.5333	0.5283	0.5234	0.5185	0.5136
−28	0.6134	0.6077	0.6021	0.5966	0.5911	0.5856	0.5802	0.5748	0.5694	0.5642
−27	0.6727	0.6666	0.6605	0.6544	0.6484	0.6425	0.6366	0.6307	0.6249	0.6191
−26	0.7371	0.7304	0.7238	0.7172	0.7107	0.7042	0.6978	0.6914	0.6851	0.6789
−25	0.8070	0.7997	0.7926	0.7854	0.7783	0.7713	0.7643	0.7574	0.7506	0.7438
−24	0.8827	0.8748	0.8671	0.8593	0.8517	0.8441	0.8366	0.8291	0.8217	0.8143
−23	0.9649	0.9564	0.9479	0.9396	0.9313	0.9230	0.9148	0.9067	0.8986	0.8906
−22	1.0538	1.0446	1.0354	1.0264	1.0173	1.0084	0.9995	0.9908	0.9821	0.9734
−21	1.1500	1.1400	1.1301	1.1203	1.1106	1.1009	1.0913	1.0818	1.0724	1.0631
−20	1.2540	1.2432	1.2325	1.2219	1.2114	1.2010	1.1906	1.1804	1.1702	1.1600
−19	1.3664	1.3548	1.3432	1.3318	1.3204	1.3091	1.2979	1.2868	1.2758	1.2648
−18	1.4877	1.4751	1.4627	1.4503	1.4381	1.4259	1.4138	1.4018	1.3899	1.3781
−17	1.6186	1.6051	1.5916	1.5783	1.5650	1.5519	1.5389	1.5259	1.5131	1.5003
−16	1.7597	1.7451	1.7306	1.7163	1.7020	1.6879	1.6738	1.6599	1.6460	1.6323
−15	1.9118	1.8961	1.8805	1.8650	1.8496	1.8343	1.8191	1.8041	1.7892	1.7744
−14	2.0755	2.0586	2.0418	2.0251	2.0085	1.9921	1.9758	1.9596	1.9435	1.9276
−13	2.2515	2.2333	2.2153	2.1973	2.1795	2.1619	2.1444	2.1270	2.1097	2.0925
−12	2.4409	2.4213	2.4019	2.3826	2.3635	2.3445	2.3256	2.3069	2.2883	2.2698
−11	2.6443	2.6233	2.6024	2.5817	2.5612	2.5408	2.5205	2.5004	2.4804	2.4606
−10	2.8627	2.8402	2.8178	2.7956	2.7735	2.7516	2.7298	2.7082	2.6868	2.6655
− 9	3.0971	3.0729	3.0489	3.0250	3.0013	2.9778	2.9544	2.9313	2.9082	2.8854
− 8	3.3484	3.3225	3.2967	3.2711	3.2457	3.2205	3.1955	3.1706	3.1459	3.1214
− 7	3.6177	3.5899	3.5623	3.5349	3.5077	3.4807	3.4519	3.4272	3.4008	3.3745
− 6	3.9061	3.8764	3.8468	3.8175	3.7883	3.7594	3.7307	3.7021	3.6738	3.6456
− 5	4.2148	4.1830	4.1514	4.1200	4.0888	4.0579	4.0271	3.9966	3.9662	3.9361
− 4	4.5451	4.5111	4.4773	4.4437	4.4103	4.3772	4.3443	4.3116	4.2791	4.2468
− 3	4.8981	4.8617	4.8256	4.7897	4.7541	4.7187	4.6835	4.6486	4.6138	4.5794
− 2	5.2753	5.2364	5.1979	5.1595	5.1214	5.0836	5.0460	5.0087	4.9716	4.9347
− 1	5.6780	5.6365	5.5953	5.5544	5.5138	5.4734	5.4333	5.3934	5.3538	5.3144
− 0	6.1078	6.0636	6.0198	5.9759	5.9325	5.8894	5.8466	5.8040	5.7617	5.7197

Temperature	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Metric units									
°C.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.
0	6.1078	6.1523	6.1971	6.2422	6.2876	6.3333	6.3793	6.4256	6.4721	6.5190
1	6.5662	6.6137	6.6614	6.7095	6.7579	6.8066	6.8556	6.9049	6.9545	7.0044
2	7.0547	7.1053	7.1562	7.2074	7.2590	7.3109	7.3631	7.4157	7.4685	7.5218
3	7.5753	7.6291	7.6833	7.7379	7.7928	7.8480	7.9036	7.9595	8.0158	8.0724
4	8.1294	8.1868	8.2445	8.3026	8.3610	8.4198	8.4789	8.5384	8.5983	8.6586
5	8.7192	8.7802	8.8416	8.9033	8.9655	9.0280	9.0909	9.1542	9.2179	9.2820
6	9.3465	9.4114	9.4766	9.5423	9.6083	9.6748	9.7416	9.8089	9.8765	9.9446
7	10.013	10.082	10.151	10.221	10.291	10.362	10.433	10.505	10.577	10.649
8	10.722	10.795	10.869	10.943	11.017	11.092	11.168	11.243	11.320	11.397
9	11.474	11.552	11.630	11.708	11.787	11.867	11.947	12.027	12.108	12.190
10	12.272	12.355	12.438	12.521	12.606	12.690	12.775	12.860	12.946	13.032
11	13.119	13.207	13.295	13.383	13.472	13.562	13.652	13.742	13.833	13.925
12	14.017	14.110	14.203	14.297	14.391	14.486	14.581	14.678	14.774	14.871
13	14.969	15.067	15.166	15.266	15.365	15.466	15.567	15.669	15.771	15.874
14	15.977	16.081	16.186	16.291	16.397	16.503	16.610	16.718	16.826	16.935
15	17.044	17.154	17.264	17.376	17.487	17.600	17.713	17.827	17.942	18.057
16	18.173	18.290	18.407	18.524	18.643	18.762	18.882	19.002	19.123	19.245
17	19.367	19.490	19.614	19.739	19.864	19.990	20.117	20.244	20.372	20.501
18	20.630	20.760	20.891	21.023	21.155	21.288	21.422	21.556	21.691	21.827
19	21.964	22.101	22.240	22.379	22.518	22.659	22.800	22.942	23.085	23.229
20	23.373	23.518	23.664	23.811	23.959	24.107	24.256	24.406	24.557	24.709
21	24.861	25.014	25.168	25.323	25.479	25.635	25.792	25.950	26.109	26.269
22	26.430	26.592	26.754	26.918	27.082	27.247	27.413	27.580	27.748	27.916
23	28.086	28.256	28.428	28.600	28.773	28.947	29.122	29.298	29.475	29.652
24	29.831	30.011	30.191	30.373	30.555	30.739	30.923	31.109	31.295	31.483
25	31.671	31.860	32.050	32.242	32.434	32.627	32.821	33.016	33.212	33.410
26	33.608	33.807	34.008	34.209	34.411	34.615	34.820	35.025	35.232	35.440
27	35.649	35.859	36.070	36.282	36.495	36.709	36.924	37.140	37.358	37.576
28	37.796	38.017	38.239	38.462	38.686	38.911	39.137	39.365	39.594	39.824
29	40.055	40.287	40.521	40.755	40.991	41.228	41.466	41.705	41.945	42.187
30	42.430	42.674	42.919	43.166	43.414	43.663	43.913	44.165	44.418	44.672
31	44.927	45.184	45.442	45.701	45.961	46.223	46.486	46.750	47.016	47.283
32	47.551	47.820	48.091	48.364	48.637	48.912	49.188	49.466	49.745	50.025
33	50.307	50.590	50.874	51.160	51.447	51.736	52.026	52.317	52.610	52.904
34	53.200	53.497	53.796	54.096	54.397	54.700	55.004	55.310	55.617	55.926
35	56.236	56.548	56.861	57.176	57.492	57.810	58.129	58.450	58.773	59.097
36	59.422	59.749	60.077	60.407	60.739	61.072	61.407	61.743	62.081	62.421
37	62.762	63.105	63.450	63.796	64.144	64.493	64.844	65.196	65.550	65.906
38	66.264	66.623	66.985	67.347	67.712	68.078	68.446	68.815	69.186	69.559
39	69.934	70.310	70.688	71.068	71.450	71.833	72.218	72.605	72.994	73.385
40	73.777	74.171	74.568	74.966	75.365	75.767	76.170	76.575	76.982	77.391
41	77.802	78.215	78.630	79.046	79.465	79.885	80.307	80.731	81.157	81.585
42	82.015	82.447	82.881	83.316	83.754	84.194	84.636	85.079	85.525	85.973
43	86.423	86.875	87.329	87.785	88.243	88.703	89.165	89.629	90.095	90.564
44	91.034	91.507	91.981	92.458	92.937	93.418	93.901	94.386	94.874	95.363
45	95.855	96.349	96.845	97.343	97.844	98.347	98.852	99.359	99.869	100.38
46	100.89	101.41	101.93	102.45	102.97	103.50	104.03	104.56	105.09	105.62
47	106.16	106.70	107.24	107.78	108.33	108.88	109.43	109.98	110.54	111.10
48	111.66	112.22	112.79	113.36	113.93	114.50	115.07	115.65	116.23	116.81
49	117.40	117.99	118.58	119.17	119.77	120.37	120.97	121.57	122.18	122.79
50	123.40	124.01	124.63	125.25	125.87	126.49	127.12	127.75	128.38	129.01

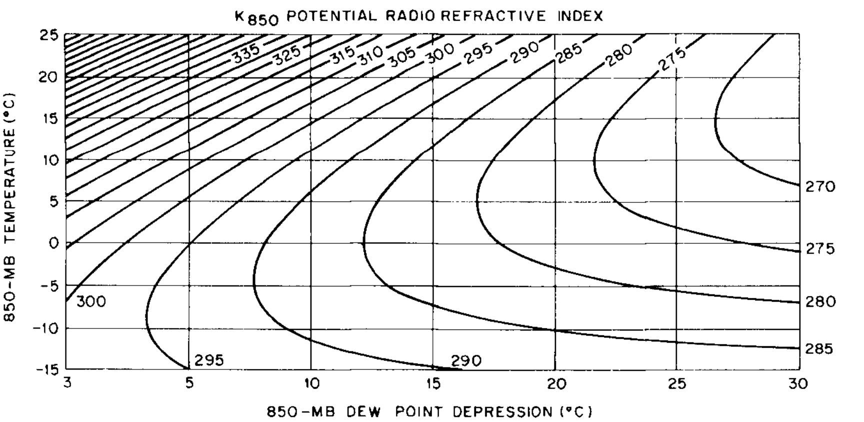

Fig 18—This graph may be used to calculate the K_{850} Index, the 850 mb potential radio refractivity. The 850 mb dew point depression is equal to the 850 mb temperature (°C) minus the 850 mb dew point temperature (°C) (i.e., $T_{850} - Td_{850}$). The lines on the graph are the K_{850} Index.

Example:

T_{850} = 15°C, Td_{850} = 10°C
Dew point depression = 15 − 10 = 5
K_{850} = 320

Table 3—The computer program to calculate K_{850}.

```
10 PRINT "ENTER T degC,TD degC AT 850 MB"
20 INPUT T, TD
30 TK = T + 273
40 TDK = TD + 273
50 E = (1/273 - 1/TDK)/1.844E - 04
60 ES = 6.1078 * EXP(E)
70 K = 74073/(TK * TK) * (TK + 5.659 * ES)
80 PRINT "K850 INDEX = ";K
90 END
```

Note— T = Temperature in °C
TD = Dew point temp in °C
TD can *never* be larger than T!
Line 30 converts °C to K
Line 50 calculates vapor pressure
Line 70 calculates K_{850}

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The Michigan Packet Radio Frequency Plan

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The date was November 17, 1985, the place was Albion College, MI, and the attendees included representatives of Packet Radio in Southern Michigan (PRISM), the Packet Technical Group (PTG), State RACES Officer James Zoss, WD8DHS, and ARES Section Emergency Coordinator George Race, WB8BGY. Packet operators from the Battle Creek, Jackson, Kalamazoo and Lansing areas were also present. Why the gathering? To discuss a frequency plan for Michigan packet radio operation. This plan was unanimously agreed on at a state wide Packet Radio Frequency Planning Conference held at the college. Details of the agreement were compiled for this article.

At the same meeting it was also agreed that PRISM would act as the packet-frequency-coordination organization as needed. It would operate under the umbrella of the Michigan Area Repeater Council and with the cooperation of other packet-related amateur groups in the state. The plan may require amendment at a future date to more accurately reflect the rapid growth of packet, new protocol or higher speed operation.

The policy of the Michigan Repeater Council does not allow for coordination of packet channels on 144 to 148 MHz. These are simplex channels that can be used by amateurs in any mode and location. All activity in this range will have to be by "gentleman's agreement," much as it already is. Anyone is free to put up a digipeater or BBS, as long as it is understood that anyone else can do the same no matter what their location. What sort of packet activity will take place on a particular channel is left to the conventions of usage, not coordination by the council.

144 MHz "Gentleman's Agreement"

144.91 Experimental and QRP
144.93 Local Area Network
144.95 Local Area Network
144.97 Local Area Network
144.99 Non digipeated Packet Simplex
145.01 Inter-LAN and Mail Forwarding
145.03 Local Area Network
145.05 Local Area Network
145.07 Local Area Network
145.09 Local Area Network

LAN frequencies would be activated in the following order:

1. 145.03
2. 145.05
3. 145.07
4. 144.97
5. 144.95
6. 144.93

The lowest numbered available frequency would be used unless it is already activated in a geographic area. It is not our intention to replace the existing backbone network on 145.01 MHz with these frequencies. These additional frequencies would supplement the network, providing room for growth as traffic and BBS activity increase.

The objective is to avoid conflict with existing voice operations on the above frequencies. It is important that packet expand in a contiguous group of frequencies and not all over the 2-meter band. This will help "carve out" a segment of 2 meters which ultimately will become recognized as a "packet subband."

220 and 440 MHz

In this coordination plan, 220-MHz channels that function in the same way as 144.91- to 145.09-MHz channels are called "uncoordinated (test)" channels. They are analogous to "test pairs" that some repeater councils set to give repeater trustees a chance to test a site or equipment before they know what type of coordination to request. Each party using such a channel knows that they can establish a repeater on the channel without coordination, but that others are also free to do so after the system is on the air.

It is important to provide room on the 220- to 225-MHz band for both 1200-baud and 9600-baud packet for two reasons. First, meaningful public-service communication cannot occur on 2 meters while stations in a Red Cross building or in an Emergency Operations Center (EOC) are simultaneously engaged in voice nets through 2-meter systems (that is virtually where all emergency voice nets are held). The packet and voice transceivers will desense each other. Using 220 for packet allows general emergency nets on 144 MHz and voice coordination of packet and logistical traffic on 440-MHz repeaters and frequencies. Also, there is room for dual-frequency digital repeaters on 220 MHz that promise to offer inherently higher rates of throughput and far fewer collisions and retries.

Second, if the FCC grants the ARRL proposal for new Novice class privileges, a potentially large number of new, inexperienced amateurs will be seeking to operate unsophisticated packet stations on 220. This large number will result in an unprecedented demand for frequency spectrum in which to use 1200-baud packet, where the stations will need to rely on wide-area digipeaters for range, since their owners will not be as skilled in antenna or equipment utilization as the more advanced amateurs now on packet. Also, with enough channels for 1200-baud work, both public service and more general packet communication can coexist on the same 220-MHz band without the traffic from one kind of activity causing problems for the other.

Single-channel store and forward digipeaters are the core of most LANs and actually serve as the network between LANs, but this may not be true in the future. Passive two-channel digital repeaters provide double the throughput rate with far fewer collisions and resulting retries. Such systems cannot be implemented on 144 MHz (or virtually not on 440 MHz) in eastern Michigan since all potential coordinations have already been made. This is not the case on 220, even in the range reserved for nonvoice activity (220.5 to 222.34 MHz). Although there is room to coordinate two-channel digital repeaters in the voice range, this is not true in Illinois, New York or California. Michigan and Ohio are lagging these states in 220 voice activity, but only by a number of years. Assigning these channels might work in the eastern half of Michigan and over most of Ohio now, but Indiana and western Michigan would have to live with throughput slow downs from voice traffic on the input frequencies of voice repeaters in the Northern Illinois and Southern Wisconsin area.

Voice traffic is frequently heard there because of propagation across Lake Michigan. If Novices are granted 220- to 225-MHz data and voice privileges, they will naturally want to use the voice spectrum for voice traffic to the detriment of packet activity. Since their numbers are potentially very large, this could be a significant problem in the future.

The Michigan Packet Radio Band Plan is also proposed for use in surrounding states recognizing that 221.00 to 222.00 MHz is reserved by the Michigan Repeater Council for coordinated nonpacket links, and has been mostly filled already. It is particularly in demand in eastern Michigan above "line A" where 420 to 430 MHz has been deleted from amateur use and given over to land mobile concerns. A plan in Illinois to do 9600 bps linking below 221.0 and 1200 bps digipeater coordination above 221.00 to 222.00 conflicts with coordinations long granted in Michigan. It is probable that no one in Illinois contemplating packet activity on 220 to 222 MHz is aware of this conflict. Communication should be established with those believed to be handling coordination there to resolve the problem before crystals and other equipment are ordered. Communications in this area is important since there is a strong likelihood that 420 to 430 MHz will be lost throughout the country in the near future, and demand for a nonpacket linking area on 220 will grow.

1200-baud two-channel
repeater outputs

(1200 bps simplex in the absence of a digital repeater in a particular area):

Output/Input
220.52 MHz/222.12 MHz
220.54 MHz/222.14 MHz
220.56 MHz/222.16 MHz
220.58 MHz/222.18 MHz
220.60 MHz/222.20 MHz
220.62 MHz/222.22 MHz
220.64 MHz/222.24 MHz
220.66 MHz/222.26 MHz
220.68 MHz/222.28 MHz
220.70 MHz/222.30 MHz
220.72 MHz/222.32 MHz

This is an inversion of the offset for 220 voice repeaters and is chosen for two reasons. By making the Michigan coordinations on these potentially overlapping channel inputs, it is possible to minimize packet traffic on those voice channels in the event there have been any voice repeater input coordinations in nearby states between 222 to 222.34 MHz (with outputs 1.6 MHz away) contrary to the ARRL band plan. More importantly, this allows two-channel digital repeaters to be collocated with standard voice repeaters operating at the high end of the band, since outputs are as far apart as possible and inputs do not need mutual protection. Obviously, if preferred, the input and output channels can be switched with no effect on the rest of the band plan.

Simplex 1200-bps channels, solely for coordinated single-channel, store and forward digipeaters and station-to-station packet simplex work, such as long file transfers:

220.74 MHz
220.76 MHz
220.78 MHz

Four 9600 bps uncoordinated (test) channels for packet linking:

220.825 MHz
220.875 MHz
220.925 MHz
220.975 MHz

If Novice activity on 220 to 225 MHz with 1200 bps outstrips the capacity of ten dual channels and three single frequency channels at some future date, the above four 50-kHz channels might be withdrawn for reassignment as ten coordinated 20-kHz single-channel, store and forward digipeater and packet simplex channels to handle the increased demand for 1200 bps spectrum on this band. This segment would then be assigned as:

220.80 MHz
220.82 MHz
220.84 MHz
220.86 MHz
220.88 MHz
220.90 MHz
220.92 MHz
220.94 MHz
220.96 MHz
220.98 MHz

Two 9600 bps uncoordinated (test) channels for packet linking:

222.025 MHz
222.075 MHz

Voice activity on the 125-cm band would continue to be coordinated consistent with the ARRL band plan:

222.34/223.94 MHz
(WA8MGO, Battle Creek)
222.36/223.96 MHz
—
—
—
223.34/224.94 MHz (Plymouth)
223.38/224.98 MHz (Cleveland)

Nineteen coordinated 50-kHz packet linking channels (430 to 431 MHz):

430.025 MHz	430.525 MHz
430.075 MHz	430.575 MHz
430.125 MHz	430.625 MHz
430.175 MHz	430.675 MHz
430.225 MHz	430.725 MHz
430.275 MHz	430.775 MHz
430.325 MHz	430.825 MHz
430.375 MHz	430.875 MHz
430.425 MHz	430.925 MHz
430.475 MHz	(Already coordinated link)

As W4WWQ suggests in the October 16, 1985 issue of *Gateway*, the ARRL packet newsletter, he "...would like to encourage some thought into use of the 420- to 450-MHz band instead of the 220-MHz band for 9600-bps linking." In some parts of the country, good, inexpensive, surplus commercial RF equipment for the 450-MHz band is available. "It seems a mistake to overlook the older equipment that has been the cornerstone of public safety communications for years." Much of that equipment is easily "broadbandable," if for no other reason that much of it was originally wideband FM gear. "Inexpensive" is an understatement, because much of it (even in solid-state form) can be had for the asking at hamfests. Tighter beamwidths and higher antenna gain for similar physical size antennas at 430 MHz rather than 220 MHz also would make it easier to coordinate links in such a way that mutual interference would be minimal.

The TAPR networking node controllerTNC will have four ports to allow most digipeaters to link in different compass directions or to a BBS. Each port would have to be outfitted with over $350 worth of 220-MHz boards, crystals, boxes and amplifier to deliver about 10 watts output per link. Multiply this times four, and each digipeater would require a $1400 expense to link in each compass direction, or $700 in a straight line, excluding antenna or feed-line costs. Many older UHF transceivers can generate 10 watts and are available for $15 to $35, allowing (after conversion costs) for linking in the four directions for under $200, again excluding antenna or feed line costs. FADCA beta testers of the K9NG modem and other manufactured boards who have shared their reactions on CompuServe, have been less than enthusiastic about the feasibility of manufactured boards for this kind of service.

[Comments or questions concerning this plan should be directed to Jim Brooker, NI8E. He is chairman of the PRISM Spectrum Planning Committee.—Ed.]

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Focus on techology above 50 MHz

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Hello Out There

When I first thought about writing this column, it seemed like there would be nothing new to talk about that hasn't already been covered in the VHF and UHF columns in the various journals. After I thought about it a little more, I realized that not only was there a nearly infinite amount of untapped VHF/UHF subject material of interest to amateurs, but also that the technology is growing and changing so quickly that the pool of knowledge is definitely going to increase.

This and future columns will touch on various aspects of VHF, UHF and microwave technology in an effort to provide readers with a little more familiarity with techniques, equipment, devices and components that may seem impossibly complex to some. There is so much stuff out there for the experimenter and builder to play with that a little familiarization with the techniques and components should tempt you to build equipment for use on the higher frequencies. Some of the columns will be general, an attempt to put away fear of the unknown; other columns will be more nuts-and-bolts oriented. In addition there will be some full-blown construction articles in upcoming issues of *QEX* to sort of bring it all together.

I welcome comments, corrections, questions and suggestions and will do my best to discuss what you, the readers, want to learn about. That's it for the introduction. Let's get on to something a little more technical.

RF Transistors: Fact and Fiction

Undoubtedly the area of technology in RF that is changing most quickly is semiconductors. In 40 years the transistor has gone from a laboratory curiosity at Bell Labs to a myriad of device types operating at frequencies exceeding 50 GHz; at power levels in the hundreds of watts; and with noise figures that are almost unmeasurable. Most of this has happened in the last twenty years!

The following discussion is by no means comprehensive, but it should provide enough familiarity and dispel enough myths that some ham experimenters will become brave enough to start fooling around with these little three and four legged critters. After first laying to rest some of the common misconceptions about RF transistors and highlighting some of their many virtues, this article will be divided into three main parts: packages, chips and applications. It will take a few months to get it all out.

The following are a few myths about RF semiconductors that need to be discussed.

1. "Transistors blow up." It is true that RF transistors are less forgiving than tubes, but modern emitter-ballasted devices are very rugged. With a few common-sense precautions they can be used safely. Once in the circuit they can be expected to last forever.

2. "Transistor amplifiers always oscillate (and transistor oscillators never do!)." The main problem with amplifier stability is that the devices have incredibly high gain at low frequencies. Most oscillations in transistor amplifiers are at low frequencies where the feedback path is actually the power supply and RF decoupling circuitry. Proper low-frequency bypassing will stabilize most finicky amplifiers. Parametric oscillations at or near the normal operating range can be caused by poor circuit design or by using a device with too much gain at a given frequency. Only in the most *difficult* circumstances should the designer have to resort to techniques such as RF feedback to calm down an amplifier.

3. "RF transistors are very expensive." At a recent ham flea market I saw 100-W VHF power devices, microwave power devices, low-noise GaAsFETs, silicon monolithic ICs and everything in between. Transistors have *definitely* hit the surplus market—sometimes at the $1 per handful level. In addition to this, many of the manufacturers will make engineering samples available to enterprising hams. It doesn't hurt to ask! In addition, there are a number of tube and transistor distributors who buy manufacturers' overruns, slightly out-of-spec devices and cosmetic rejects and make them available in small quantities at reasonable prices. Today, devices for a 2-meter quarter-kilowatt linear can be purchased for less than the cost of a socket for a 4CX250!

4. "RF transistors are designed for class-C operation and do not work well in linear service." This may have been true 10 or 15 years ago, but there are now emitter-ballasted transistors designed specifically for linear operation up to at least 4 GHz. This doesn't mean you can't overdrive a solid-state amplifier and make a mess all over the band, but you can do that with a tube too! With a little extra effort, class-C devices normally work well in class-AB linear service. There is no reason why common- base class-C devices cannot be forward-biased for linear service with the proper precautions.

5. "Transistors are for low-power and low-frequency applications only." Of course, as we go higher in frequency and power we come closer to the "edge" of the state of the art. The technology is advancing at a very high rate. Today there are silicon power devices operating at 300 W per device at VHF and a couple of watts linear class-A at 5 GHz. Gallium-arsenide (GaAs) devices are operating with moderate power above 40 GHz, and of course these low-noise devices have all but completely taken over the market for high-frequency receiving applications.

6. "GaAsFETs cost a lot and blow up before you can get them in the circuit." Improvements in wafer processing techniques and high-quantity production have brought the prices of GaAs receiving devices down to what bipolars were a couple of years ago. Devices suitable for use up to at least 1296 MHz are now available in inexpensive plastic packages. Improvements in processing technology have also made the devices much more rugged and less sensitive to static charges. Care should still be used when handling these devices, but to be honest, lightning is the only thing I've ever lost a GaAsFET to.

7. "Transistors are too small to work with." This is true sometimes! The size of the human finger has not decreased with the advancement of transistor technology. Invest in a good set of tweezers. The old 300-W soldering iron won't cut it any more either.

Transistors are compact, run on nonlethal voltage, use a single power supply and last forever when used within their ratings. The disadvantages are low power relative to big power tubes, and comparatively high cost for the more state-of-the-art microwave-type devices.

Next month: Transistor packages.

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Spreading the Word

During May 1985, I had the pleasure of speaking about UHF and microwave receivers at the Northeast VHF Conference in Nashua, NH. Judging from the number of attendees, it appears that serious VHF+ work is on the increase. In fact, so many people attended and so much good information was available that two separate formal sessions, plus informal band-user's groups, were going on at the same time.

While I would like to report on what Stephen Powlishen, K1FO, had to say about building a power amplifier with a full 1500-W output on 432 MHz, I cannot. Why? Our talks were scheduled at the same time.

I suppose I could have asked the other speakers for a set of their notes or handouts, but that would have deprived me of the benefit of hearing what that knowledgeable speaker stressed or what was said at an impromptu band session. I could have brought my pocket recorder and had someone else tape the session, but what would I do when the speaker says, most emphatically, "Be sure to insulate this component from that lead over there, especially when varying this control." No, sound isn't good enough either. This situation becomes increasingly worse if the conference is at a location or time outside your range. With the electronic equipment VHF+ers have access to, doesn't it seem a shame that *all* the good words (and works) cannot be made available to everyone everywhere?

The solution to this problem, if you have not guessed, may be to videotape each session of the conference and make the tape(s) available for loan at a nominal fee to cover preparation and postage. At the start there may be problems, but nothing that can't be solved. My employer tapes many technical presentations (several each week of staffers and invited professionals). There are no insurmountable technical or legal problems involved. Let's go conference organizers; get your video committee started **NOW!**

I've known of cases where videotaping was not practical, but the speakers provided notes. These notes were compiled by the conference organizers and distributed to attendees. VHF+ conference attendees, being the breed that we are, are relatively motivated. We not only make sure that a copy of any interesting information is obtained, but we will also take copious notes and even bother the speaker for additional data. (I usually bring a batch of self-addressed, stamped envelopes to give to those wanting data at home or in the office. I also expect to receive QSL cards, business cards, and so on when I attend a conference as a speaker or otherwise. It's all part of spreading the word.)

Enough I say! There are too few VHF+ers in this hemisphere, compared to Europe, for example. We should not allow the loss of *any* worthwhile data! If the conference organizer is willing to publicize their notes, let me know and in turn I will publish the relevant data in my next column. If no formal availability is planned, I would still like to receive the handouts (conference or general). I could distribute the information through my column or for an SASE. This will combine my two objectives: to hear what is going on, and to make sure any other interested VHF+er hears about it also.

Table 1
GaAsFET Performance

Type	Approximate NF/Ga					
	0.96 GHz	1.3 GHz	2.3 GHz	3.5 GHz	5.7 GHz	10 GHz
2SK574 ($7)	0.4/17+	0.5/17	0.6/15	0.7/14	1.3/12	2.3/10
2SK575 ($22.50)	0.17/15+	0.2/15	0.25/14	0.3/13	0.4/12	1.1/10+
2SK576 ($13.50)	0.22/17+	0.25/17	0.28/16	0.35/15	0.5/14	1.4/11+

Has Super FET Arrived?

How far has the really low-noise GaAsFET come in the past few years? This rare and expensive ($150) device appeared around 1978. It provided a 432-MHz noise figure which is now easily beaten by any of several $10-15 components.

Present day GaAsFETs don't seem to punch through as easily as those earlier devices for most handling conditions. I lost one of my first 3 devices ($100 apiece), but have not lost any during the last 3 years. Could it also be summarized that builders have a better understanding of how to handle these components?

I referenced data sheets to find the high cut-off frequencies of present-day devices for someone who had a trio of Sony components. Not only do these devices have 2SK numbers (the equivalent of American 2N designations for devices with fairly firmly fixed characteristics), but they also have relatively low prices and small quantity availability. (While I have not yet acquired any of these GaAsFETs, the contact appears to be J. Lim, Sales Administrator, Sony Corp of America, Component Products Div—Semiconductor, 15 Essex Rd, Paramus, NJ 07643.)

I have tabulated apparent noise figure (NF) and associated gain (Ga) values from their data sheets for each type. Prices given are approximate figures for a 1-19 quantity. You decide if the superFET is among us!

If you did not already spot it, go back and check the specs on the most expensive ($22.50) device. I eagerly await not only my own devices, but reports of how they fare with other VHF+ers.

RF Design Holds First Design Contest

RF Design magazine has announced it will sponsor a circuit design contest during the first quarter of 1986. Editor Jim MacDonald said the purpose of the contest is to encourage design creativity and to share design ideas among the RF community. The contest will be limited to designs of active RF circuits operating in the UHF range or below. Contest officials said an active circuit is defined as one that introduces gain or has a directional function, for example, an amplifier, oscillator, mixer, modulator or demodulator.

Entries will be accepted from now until April 15, 1986. Contest rules state the design must be original work by the entrant and not previously published. If the design develops from the designer's employment, the employer must give permission to enter it in the contest. Patent or copyright infringement will disqualify a design.

Judging criteria will include originality of concept, imaginative application of a component or device, signficant cost or labor saving, elegance of design, exceptional performance, usefulness, clear description of function and reproducibility. All circuit components must be available for purchase. The designer must be able to document to the satisfaction of the judges that the circuit operates and performs as described.

Each entry must include a complete description of the circuit and its function and parts list. At least one complete circuit diagram is necessary, and additional drawings and photographs may be included for clarity.

The contest judges will be Gary Breed, K9AY, *RF Design* technical editor, Andy Przedpelski, vice president for development, ARF Products, Inc, and James W. Mize, Jr., WØAAN, senior research engineer, Lockheed Missile and Space Co.

Entries may be sent to *RF Design,* 6530 South Yosemite St, Englewood, CO 80111. Designs remain the property of the designer, but prize-winning designs may be published in *RF Design* magazine. Submission for the contest implies consent to such publication. The winning entrant will also receive a Hewlett-Packard 41 programmable calculator.

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Bits

New ROM Pac From Hewlett-Packard Unites Power and Portability at a Lower Price

A new HP-82479A data-acquisition ROM pac links the HP-71B handheld computer to the HP-3421A data-acquisition control unit to form a powerful, portable, low-priced data-acquisition system. This combination enables users to perform tests and product evaluation in the field as easily as at a workstation.

The HP-82479A ROM software module allows front-panel control of the HP-3421A with a computer keyboard overlay, strip charting with the HP ThinkJet printer, large-screen monitoring of near real-time data, data logging with menu driven software, 45 BASIC keywords for instrument control and data transfer.

The HP-71B handheld computer and the HP3421A data-acquisition control unit may now be combined to provide a powerful, low-priced solution in the laboratory, field or the production line. (Photo courtesy of Hewlett-Packard Co)

The HP-71B is a handheld computer that comes with 17.5 kbytes of user memory, a BASIC operating system, a clock, calendar and three timers, battery operation and a user-definable keyboard.

The HP-3421A data-acquisition control unit scans up to 30 channels, measures ac and dc volts, two- and four-wire ohms, frequency and temperature. It can also read and write digital information, and provides actuator relays.

To help you configure a powerful and versatile system, HP recommends the following:

- HP-82479A data-acquisition ROM ($195);
- HP-71B data-acquisition control mainframes ($1,450);
- HP-3421A data-acquisition control unit for test and control;
- HP-ThinkJet printer for tabulating and plotting tasks ($495);
- HP-9114A portable 3 1/2-inch flexible-disk drive for increased mass-storage capacity ($795)

All are currently available with a 6-week delivery ARO. For more information on this system, mail inquiries to: Inquiries Manager, Hewlett-Packard Company, 1820 Embarcadero Road, Palo Alto, CA 94303.