Fig. 2 demonstrates that this multiplexer circuit introduces negligible noise to the signal and that the sampling sequence is maintained throughout the entire ascent. A fixed 37.7-kilohm resistor was substituted for the humidity sensor shown in Fig. 1; the data of Fig. 2 recorded for this resistor varied over a scale range from 52.0 to 51.2. A similar scale reduction of 0.7 was observed when a 37.7-kilohm resistor connected directly to a radiosonde was tested in a cold chamber over the range of temperatures encountered during an ascent. The observed ordinate shift cannot, therefore, be attributed to the multiplexer. The switching duration increased from 9 sec in Fig. 2a to 15 sec in Fig. 2b due to a decrease in the B-voltage driving the ring counter.

Two modified radiosondes were returned after having been dropped by parachute and exposed to weathering in the field; both multiplexers operated satisfactorily even though one of the sondes was damaged beyond repair.

Acknowledgments. The authors would like to express appreciation to Dr. P. M. Kuhn and Mr. James Maynard for their cooperation in conducting the radiometersonde ascents. They also wish to thank Prof. V. E. Suomi for his stimulating comments.

The development of the multiplexer described here was supported by Environmental Science Services Administration grant WBG 27.

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A Note on Standardization of Performance of WSR-57 Radars[1]

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21 September 1965 and 25 March 1966

1. Current standardization procedures

References to the "standardization" of the U. S. Weather Bureau's network of WSR-57 radars have appeared in several publications since the method was given in the Weather Surveillance Radar Manual (U. S. Weather Bureau, 1960) and later presented by Bigler and Brooks (1963). Without exception, the references have either stated or implied that the attempted standardization achieved the goal stated by those authors when they wrote in 1963 ". . . thus, all WSR-57 radars operate with the same relative receiver performance." When the method is applied to the measurement of reasonably large echo signals on the A or R scopes it is a logical improvement over earlier techniques. However, it is currently being erroneously applied to WSR-57 PPI and RHI data in the determination of echo peripheries and areas in both operational and research situations. Consequently, it warrants a clarification of the actually rather narrow application of the statement.

The method used to "standardize" relative receiver performance, summarized from the Weather Surveillance Radar Manual and still in use is as follows: Three lines are placed on the A or R scope face and the total signal amplitude adjusted such that the top line represents receiver "saturation" and the bottom the base line for the A scope trace from the linear receiver. The third line is 30–40 per cent of the way up from the base line and represents an arbitrary level to which the top of a −103 dbm test signal is set by adjusting the bias voltage or IF gain control. Any time the radar operator wishes to estimate the strength of a signal which *exceeds* that level he applies attenuation to it until he reduces it to the −103 dbm reference level. Then, noting the amount of attenuation applied, he (algebraically) adds it to the −103 dbm value, adds a correction for the difference between the actual transmitter power output and the 500-kW standard, refers to a chart for range correction, and reports the estimated intensity category. A desirable feature of this intensity measurement technique is that for radars having minimum detection capabilities better than −103 dbm, measurements are made in the middle range of the A scope where signal amplitude resolution is much better than at the minimum signal detection region where it would otherwise have to be subjectively distinguished from noise. This standardization procedure is valid to this point.

However, the only reason for the procedure is the fact that it has not been economically possible to standardize either the power output levels of the trans-

[1] Contribution No. 686 from Institute of Marine Science, University of Miami.

mitters (a *small* correction) or the performance of the various radar receivers (a relatively *large* correction). Consequently, the middle line was placed on the A or R scope to represent a signal level considerably poorer than the capabilities of most of the radars in the system, but normally within the capabilities of even the less sensitive receivers. The erroneous implication has been left with both operators and users of the data that manipulation of IF gain has "degraded" the performance of the better receivers to a given "standard," and that this is reflected in the appearance of the other radarscopes and the data recorded on them. As a case in point, a recently published manual intended for extensive use in training and operational programs using WSR-57 radar data states, ". . . these radars are calibrated to give a minimum detectable signal of −103 dbm . . ." (United Aircraft Corporation Systems Center, 1965). In addition, private communications with Weather Bureau radar meteorologists and radar technicians as well as university researchers indicates that they, too, are under the complete misconception that decreases in gain have rendered the WSR-57 radars "standard" such that quantitative use may be made of the data in the "minimum signal detection" region.

Actually, within the ranges of gain adjustments necessary to accomplish the above, the dynamic range of the receiver (the range of signals from the minimum detectable signal, MDS, normally the smallest signal which can be discerned just above the "noise" or "grass" level on the A or R scope, to the saturation or maximum level of the WSR-57 or other U. S. Weather Bureau radars) is *not* simply shifted as implied in the charts of the Weather Surveillance Radar Manual (3–44 to 3–46) but is actually extended. This is true because the "grass" or "noise" amplification level is reduced *without* appreciably reducing the MDS (lower end), while the saturation level (upper end) actually represents considerably larger signals as the gain or amplification is reduced[2]. While Bigler and Brooks (1963, p. 333) note that such changes in dynamic range take place, they do not consider that the initial changes occur at the upper, or saturation, end of the signal amplification scale without changes in the lower end (the *only* levels measurable by a data analyst). Notice that although the −103 dbm reference line is valid when set according to the above procedures, the operator of such a radar is still capable of seeing signals *below* that reference line on the A or R scope as well as on his PPI and RHI scopes. Since he gathers echo intensity information from the "standardized" line on the A or R scope, this information is valid. However, echo intensity is only a portion of the data reported.

[2] Tests on both of the University of Miami MPS-4 and CPS-6B (modified) receiver systems, as well as the Miami U. S. Weather Bureau WSR-57 show that between 8 and 16 db of attenuation is necessary before the MDS is appreciably lowered on the PPI scopes. The technical reasons for this and the methods of compensation need further study for each system.

Echo size and shape, however, have *not* been reduced to a standard by that process. The more efficient receivers will portray signals as small as one half to one tenth of those of receiver systems which actually have an MDS approaching the −103 dbm "standard." Although intensity has been properly reported operationally, there is no provision for standardizing on the other echo characteristics, including horizontal and vertical size and shape.

The errors committed operationally on the above will be only at the lighter rainfall rates and may therefore not be too serious. Their magnitude will depend on the gradients and values of precipitation intensity of the echo. Although Bigler and Brooks make only a modest claim for accuracies of about ±5 db for *operational* quantitative precipitation estimates, the situation for all users and viewers of the relatively well documented radarscope film is far more serious. In such use, the possible errors are about *two to three times* their projected operational accuracies for most radars. Lights around the azimuth circle (on the film) are coded such that attenuation applied to the receiver is accurately shown for each frame of film. Unfortunately, neither the echoes on the radarscope nor the data lights reflect the fact that any attempt has been made to "standardize" the system. Both the power transmitted and the actual MDS of the receiver for each attenuator level used are needed to qualitatively interpret the radar scope data from the film.

2. Recommendations for the collection and use of filmed data

a) At the present time the transmitter and receiver performance levels are not conveniently available with the filmed weather radar data. (Indeed, the average user is not aware of his need for it.) Since the performance of the entire transmitting and receiving system is relatively stable from day to day, and since it is established periodically as the basis for all operational intensity estimates, it is suggested that MDS and peak power transmitted be separately entered on the camera data card at the same time they are established for the calibration log, presently once each week.

b) Since the film currently records echo data which are quantitative only at MDS, a long series of test signals should be photographed with the receiver "standardized" as above, including each of the "attenuation" settings. Such tests should be run with the weekly performance checks above with test signal levels appearing on the filmed data card. Only in this way can the quantitative aspects of the film be realized and the MDS at the "standardized" mode known to the analyst.

c) All users of WSR-57 film should be made aware of the limitations of the data portrayed *both* when such data are *un*compensated for the real MDS (*not* the −103 dbm "standard") and power transmitted, as well as when the user attempts to accomplish the compensation using data gathered on film during the technician's weekly "calibration" checks. He should realize that he cannot adequately compensate without knowing the full effect on the echoes of the receiver changes which the operator or technician made in an attempt to achieve the "standardization."

3. Recommendations for operational standardization

a) Depending on the intensity, a small change in the MDS can have a large effect on echo area. Consequently, echo areas are presently subject to large errors while attempts are made to standardize only echo intensity. To partially correct this situation, tests should be run on each system to determine the amount of attenuation necessary to actually degrade the receiver system MDS to the −103 dbm level. Such procedures cannot provide accurate quantitative measurements of signal intensities which are made on the A or R scopes, but should help to standardize the echo areas and shapes somewhat on the PPI and RHI scopes for routine transmissions of this aspect of radar weather data.

b) Since peak power transmitted is generally about as stable as receiver performance, it would also seem prudent to compensate for variations from the standard 500 kW by adjusting receiver gain instead of making many individual operator corrections on a chart during the course of a day.

Even when a "calibrated" radar has been "standardized" to the extent indicated above, many discrepancies remain in the procedures which affect a given radar's precipitation estimates. It is not intended to imply that any of these have been treated fully here. Instead, we seek to end the misuse and possibly erroneous concept which many presently hold of the U. S. Weather Bureau's logical program to standardize their radar weather reporting and to suggest methods which might help all of us who use their increasingly improving radar data both operationally and in research.

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