Ten centimeter propagation measurements

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ELECTRICAL ENGINEERING AND RADIO BRANCH

TEN CENTIMETER PROPAGATION MEASUREMENTS

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ELECTRICAL ENGINEERING AND RADIO BRANCH PRB-147

TEN CENTIMETER PROPAGATION MEASUREMENTS

Propagation tests fall into two general classes. In one kind of measurement an attempt is made to obtain quantitative correlation between signal level and various factors such as meteorological conditions and path profile. Because of the large change in radio propagation accompanying a small change in weather, and because of the inhomogeneous nature of the atmosphere, this type of measurement is very difficult and expensive.

The other class of measurements, which could be called statistical measurements, are based on the hope that after a certain length of time the changing conditions over the path will begin to repeat themselves, and that if the deepest fade and the average signal be taken over a long enough period they will be characteristic of the path. Even when the period of examination has been satisfactorily long, the results still apply to the particular path only, although a certain amount of extension to paths of the same general nature would be difficult to avoid.

The nature of the results we obtained was determined by the problem presented by the Canadian Railways. This was to assist in setting up a chain of microwave links from Toronto to Montreal to serve as a test of the general usefulness of such links. The National Research Council and the Railway Engineers collaborated on a survey and choice of sites. The National Research Council built the equipment and acted in an advisory capacity during field trials. The field trials were done entirely by the railway engineers.

In picking out the profiles, the maximum clearance between the radio line of sight and ground was sought. Where the line of sight was close to ground the link was made short. The general procedure was to pick the high spots from a topographical map, join them, and plot the resulting profile. Coordinates curved to account for normal refraction were used. This was comparatively easy in hilly country, but in part of the path west of Ottawa, where the country was rather flat, considerable time was spent plotting different paths without obtaining much improvement.

Men and equipment were provided for transmitting over one link at a time first, and it was decided to use these to obtain tentative data quickly for each of the fourteen links.

Then long term tests were to be made over a number of links in order to study them thoroughly. At the present time, six months after starting, the first part of the programme has just been completed. From the time the equipment was put on the read, it has been transmitting signals 25 percent of the time. In judging this figure, the difficulties of a Canadian winter and Laurentian topography must be taken into account. At Blue Mountain, for instance, the temperature was 20 below zero when the equipment was hauled in. It was necessary to use rope and sled, One man froze both feet.

For the short tests, transmitter and receiver were mounted in separate trailers, each provided with a truck. The towers and aerials were strapped on top. Three men attended each unit continuously.

In choosing the transmitter and receiver, it was decided that they were to be used exclusively on likely, optical paths. This being the case, a low power reflex klystron was considered adequate, and much less trouble than a magnetron and pulser. The receiver chosen was a narrow band superheterodyne with automatic frequency control. Operation from a modulated signal with a narrow audio bandwidth was held in reserve in case more sensitivity was needed, but actually the C.W. signals gave adequate sensitivity.

Four foot parabolic mirrors were chosen as aerials because they were believed to have the highest gain consistent with reasonable weight. The transmitter was separated from its power supply and mounted in a thermostatted box on top of the tower. It seemed like rather a large job to do this for the receiver and we were forced to use telcothene cable between the receiver paraboloid and the receiver. Measuring the loss in the cable was made part of the routine of setting up, and actually it gave very little trouble.

Figure 1 shows the transmitter and shields. A thermistor acting as a simple pick up was used as a monitor and mounted inside the can. The indication of the thermistor bridge was recorded continuously.

The receiver circuit was a narrow band superheterodyne designed for the maximum possible stability of gain. An automatic frequency control held the frequency within satisfactory limits, so the only problem was to keep the transconductance of the tubes constant. Finally, the fixed bias for the AVC stages, the plates, screens and filaments were all supplied from a common stabilized supply. It was possible to cancel out a large part of the fluctuation in gain caused by small changes in supply voltage by choosing the operating point of the AVC stages properly. As a result of this effort, the IF gain was stable to within 1/2 db per day. The output meter was linear over a range of 40 db. We found this range adequate without the use of extra attenuators. The reading was recorded on an Esterline Angus meter. The gain was checked every hour against a signal generator. In the long term tests daily checks can be used.

Figure 2 shows the receiver and the signal generator. The signal generator consisted of another McNally tube mounted in a well shielded cavity. The output was fed to a piston attenuator with a thermistor built in one end. The reading of the piston attenuator after the thermistor reading had been set to the standard value, provided the reference level for the incoming signal.

The reference level was chosen for each run somewhere near the average of signals received. If any doubt was felt about the calibration of the receiver, it could be recalibrated from the piston attenuator in the field. The cable attenuation was also measured against the signal generator. Before tests were started, the transmitting paraboloid and receiving paraboloid were set up 400 feet apart and the output at the receiver measured with a thermistor bridge. The two aerials were so placed that ground reflections could not occur. The value of received power measured here was used to calculate the free space field for the various stations.

Figures 3 and 4 show the profiles of the 13 links, and opposite them, graphs of a 3-day run. The links appear in order from Montreal to Toronto. The best profile was the Rigaud-Montebello link. This link averaged well above the free space value. Some of the other links averaged as low as 10 to 15 db. below the free space value in spite of the fact that for all paths the radio line of sight cleared the tops of trees by at least 50 feet. The best paths were those with the clearest profiles, and to this extent the results may be said to agree with theory. With the meteorological conditions and the ground reflections unknown, it is not possible to obtain any satisfactory comparison with calculated values of transmission.

The deepest fade recorded is shown on the Montreal-Rigaud run (Figure 3, top graph). It was about 30 db. below free space and occurred during a severe sleet storm. Up to 10 db. may be due to ice on the aerial. The fade lasted long enough to allow checking the aerials for snow and water.

Most of the curves lie within plus or minus 5 db. but the general shape of the curves show that they are not long enough to draw any accurate conclusions about fading. Some paths are very steady, especially those shown in Figure 4.

In conclusion it should be stated that these results are presented only as tentative values for line of sight propagation over typical Canadian country. Some was rough, rocky, and heavily treed, some of it was rolling farm land.

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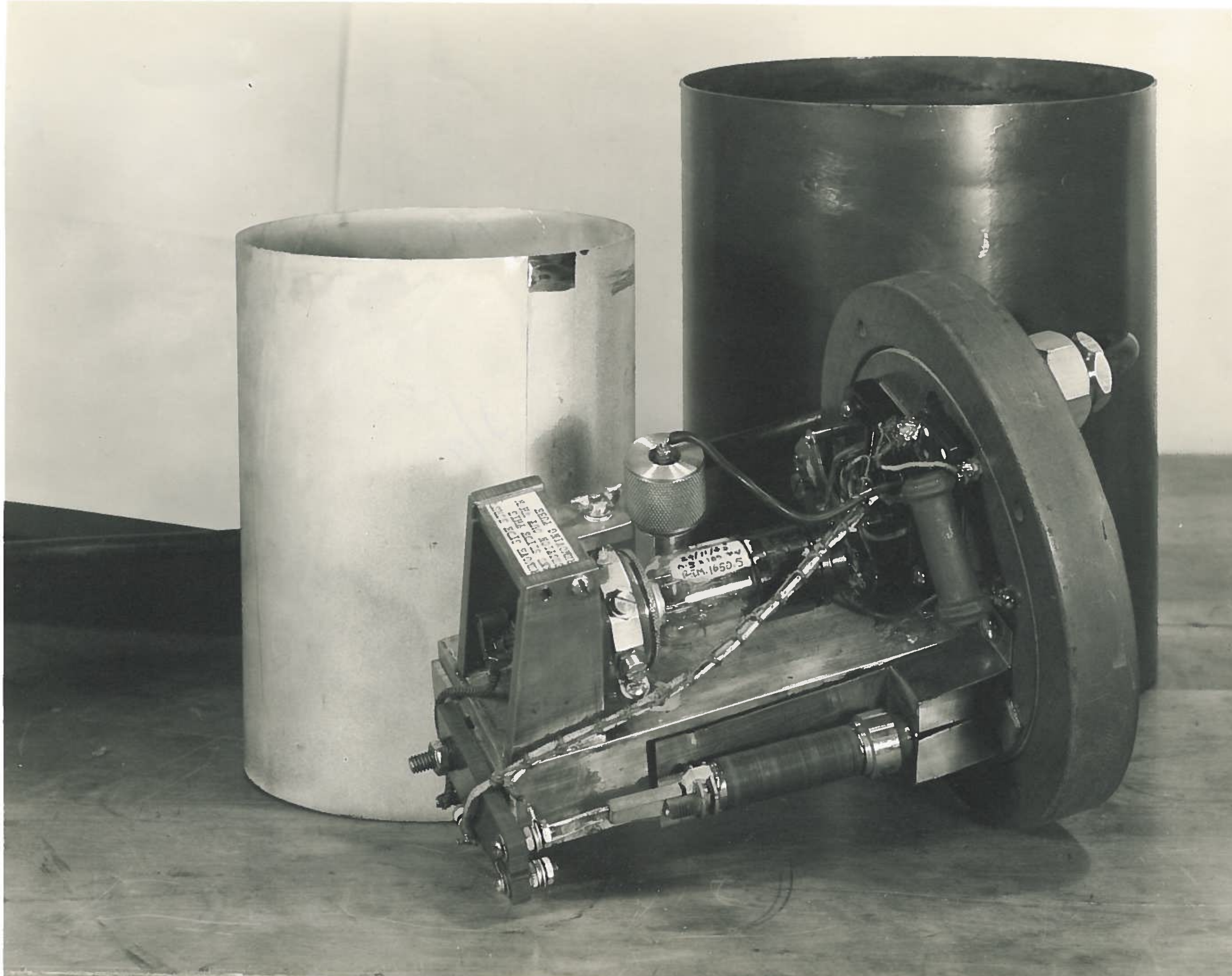

FIGURE 1 -- TRANSMITTER AND SHIELDS

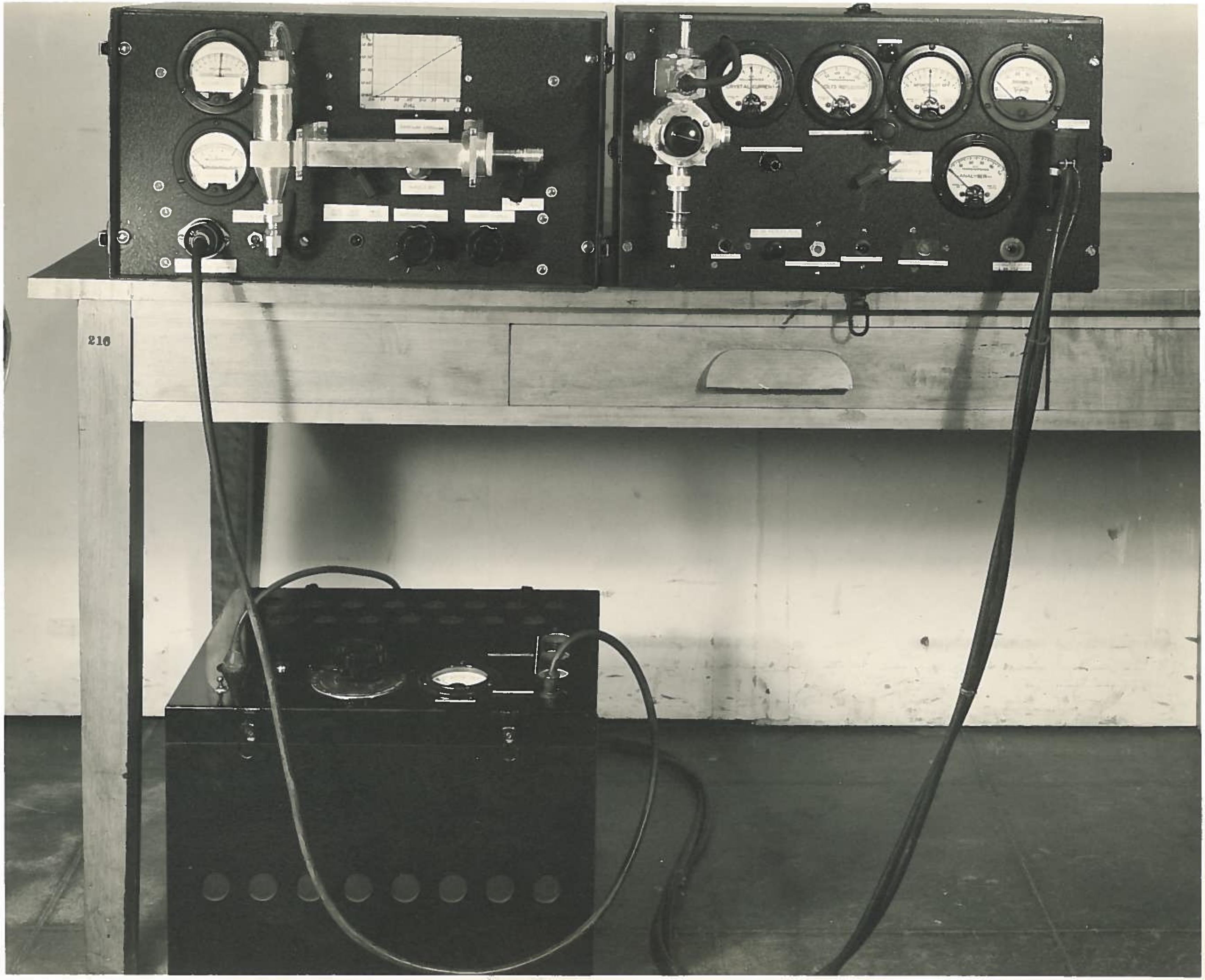

FIGURE 2 -- RECEIVER AND SIGNAL GENERATOR

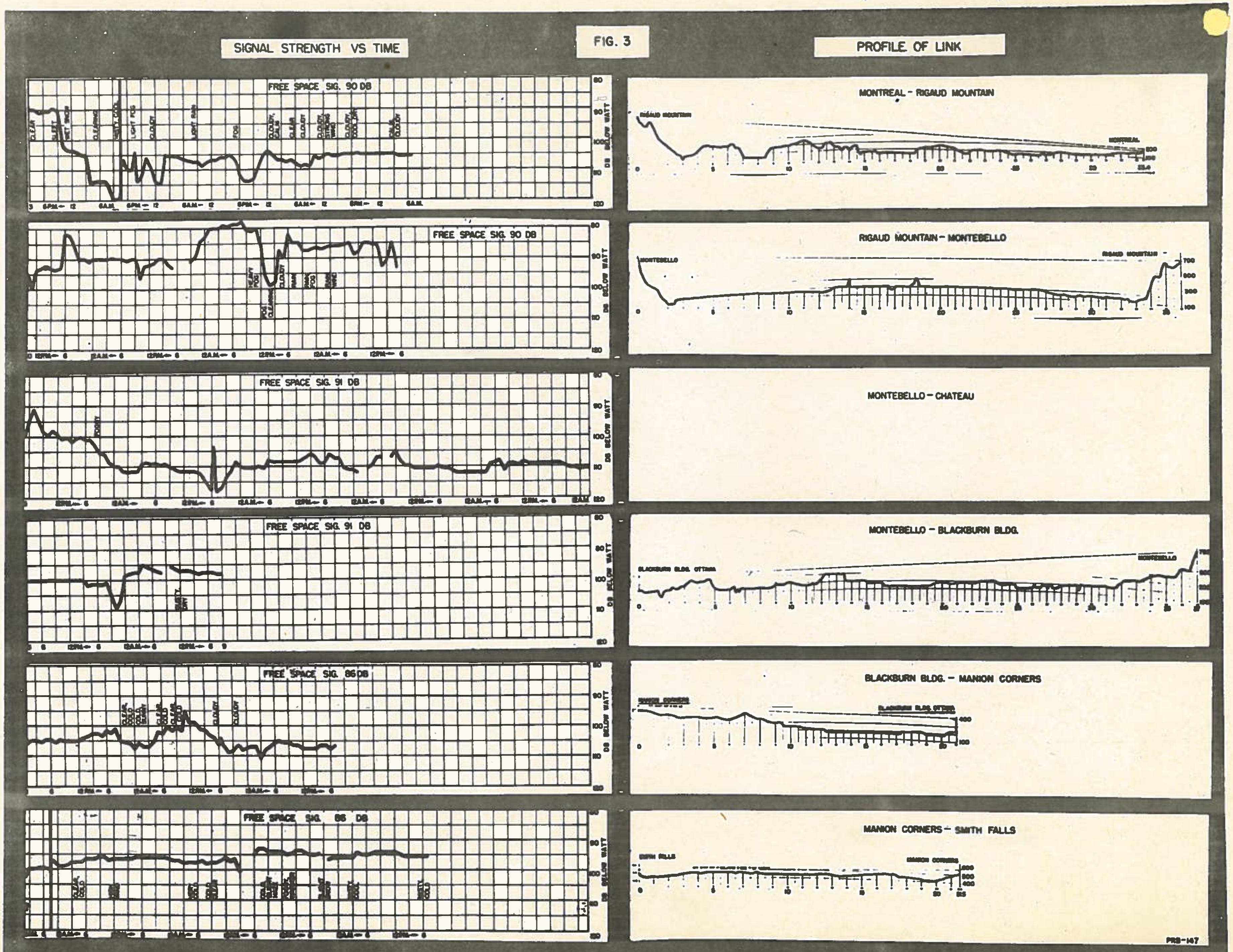
SIGNAL STRENGTH VS TIME
PROFILE OF LINK
FREE SPACE SIG. 90 DB
FREE SPACE SIG. 90 DB
FREE SPACE SIG. 91 DB
FREE SPACE SIG. 91 DB
FREE SPACE SIG. 86 DB
FREE SPACE SIG. 86 DB
DB BELOW WATT
MONTREAL - RIGAUD MOUNTAIN
RIGAUD MOUNTAIN - MONTEBELLO
MONTEBELLO - CHATEAU
MONTEBELLO - BLACKBURN BLDG.
BLACKBURN BLDG. - MANION CORNERS
MANION CORNERS - SMITH FALLS
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FIG. 3

SIGNAL STRENGTH VS. TIME

FIG. 4