

BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, D.C. 20554

<p>In the Matter of AMENDMENT OF PARTS 2 AND 3 OF THE COM- MISSION'S RULES TO PROVIDE TEMPORARY INTERFERENCE PROTECTION TO THE UNIVER- SITY OF ILLINOIS RADIO ASTRONOMY SITE ON FREQUENCIES BETWEEN 608 AND 614 MC/S, TELEVISION CHANNEL No. 37</p>	}	<p>Docket No. 15022 RM-180</p>
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REPORT AND ORDER

(October 4, 1963)

BY THE COMMISSION (COMMISSIONER LEE DISSIDENTING AND ISSUING A STATEMENT IN WHICH COMMISSIONER COX JOINS) :

1. On March 27, 1963, the Commission adopted a Notice of Proposed Rule Making in this proceeding calling for comments on or before May 1, 1963, and for reply comments on or before May 10, 1963. The latter date was subsequently extended to May 17, 1963, at the request of one of the interested parties.

2. The Commission proposed to amend Parts 2 and 3 of its Rules to delete the availability of Channel 37 (608-614 Mc/s) for authorization in the broadcasting service, until January 1, 1968, in an area circumscribed by a radius of 600 statute miles centered on Danville, Illinois, the location of the University of Illinois radio astronomy observatory. However, because of the possibility that comments responsive to the Notice would indicate the need to adopt a temporary protection plan involving a radius other than that proposed, the Commission stated that it would issue no final authorizations for the use of Channel 37 anywhere within the United States until the termination of this proceeding. In order to delineate the type of information necessary to permit a considered judgement in this proceeding, a series of six questions was directed to radio astronomy interests. These questions and responses thereto are treated in detail in subsequent paragraphs.

3. Approximately 140 comments were filed with the Commission in response to its Notice of Proposed Rule Making in this proceeding. All fell within two sharply defined categories: 1) broadcasting interests, who, in general, considered the Commission's proposal a fair and equitable compromise solution to a difficult problem; and 2) radio astronomy proponents, who considered the action proposed by the Commission inadequate to meet the needs of the radio astronomy service in general. The latter category is divisible further, about

25 being formal in nature and the remainder of varying degrees of formality from individual members of the public either directly or through their Congressional representatives.

4. Comments were filed by the following broadcasting interests:

Spanish International Television Company, Inc. (SITC)
 Trans-Tel Corporation
 Progress Broadcasting Corporation, and
 Association of Maximum Service Telecasters, Inc. (AMST)

The first three are TV applicants for Channel 37 at Paterson, New Jersey, where it is presently assigned. SITC subsequently filed comments in response to those filed by the University of Illinois, and AMST filed in response to the general tenor of comments filed by radio astronomy proponents, wherein an exclusive allocation on a permanent basis was advocated for the radio astronomy service in the band 608-614 Mc/s.

5. Formal comments were filed by the following radio astronomy interests:

President, Graduate Research Center of the Southwest
 Director, Department of Terrestrial Magnetism, Carnegie Institution of Washington
 National Science Foundation
 Director, Radio Astronomy Observatory, University of Michigan
 Associated Universities, Inc. (for the National Astronomy Observatory)
 University of Illinois
 University of Maryland
 Federation of American Scientists
 Director, Stanford Radio Astronomy Institute
 Geophysical Institute, University of Alaska
 National Academy of Sciences—National Research Council
 President, University of California
 The Pennsylvania State University
 National Center of Atmospheric Research
 Yale University
 Stanford University
 California Institute of Technology
 American Museum Hayden Planetarium
 Director, Radio Observatory, University of Florida
 Dr. R. M. Fristrom
 Boeing Scientific Research Laboratories, and
 Mr. C. L. Seeger, Department of Astronomy, University of California, Berkeley.

Additionally, on June 7, 1963, the City Council of Ann Arbor, Michigan, adopted and transmitted to the Commission a Resolution on behalf of the University of Michigan radio astronomy program in particular, and the radio astronomy service in general, seeking the preservation of Channel 37 for that purpose.

6. The initial comments filed by Spanish International Television Company, Inc. (SITC) expressed the view that:

- (a) the Commission's proposal is more than adequate to meet the needs of the University of Illinois;
- (b) if limitations upon the use of Channel 37 by television stations were imposed, they should be no harsher than those proposed by the Commission;
- (c) Channel 37 could be used by television stations of either Canada or Mexico under existing agreements, without observing the mileage or hour limitations;

(d) the University of Illinois had neither alleged nor filed factual data at that time to support a supposition that television operations on Channel 37 in New Jersey or Florida would cause harmful interference to the observatory at Danville, Illinois; and

(e) with regard to the hours-of-use limitation, effective radio astronomy observations could not be made during daylight hours; sunrise may occur as early as 4:30 AM in June and July at Danville; and therefore, the time limitation on television use of the channel is unduly harsh.

SITC, as well as Trans-Tel Corporation, took the position that adoption of the Commission's proposal would drive a wedge into the middle of the UHF-TV band where no particular need for the band in question had been advanced (other than equipment built in disregard for the Table of Frequency Allocations).

7. Trans-Tel Corporation took exception to the proposal to prohibit the use of Channel 37 by television stations between midnight and 7:00 AM local time on the ground that the television station might have to operate during that period to be viable, particularly in view of competitive difficulties in the same area. Trans-Tel stated the Commission may wish to allot a different UHF channel to New York City with but minor waiver of the mileage separation requirement and cited Channel 14 as a case in point. That channel is used by WWOR-TV, Worcester, Massachusetts, but could be re-used in New York City on the basis of a rule waiver. Trans-Tel reportedly was discussing the matter with WWOR-TV to get the reaction of the latter to such a waiver.

8. Association of Maximum Service Telecasters, Inc. (AMST) recognized the Commission's proposal as a compromise solution and, therefore, did not object to the proposal. AMST cautioned, however, that its acquiescence in this case could not be taken as applicable to any other channel or to greater limitations on Channel 37 than initially proposed. AMST, in its reply comments, requested the Commission to disregard all requests for permanent, exclusive allocation of Channel 37 to the radio astronomy service on the grounds that such requests were beyond the scope of this proceeding and that, in any event, such action would be premature prior to the conclusion of proceedings in Docket No. 11997.

9. Progress Broadcasting Corporation supported the Commission's proposal as a fair and equitable compromise solution to a difficult problem.

10. Of the radio astronomy proponents filing formal comments, relatively few responded specifically to the previously-mentioned six questions directed to them. Those questions, and the replies thereto, are set forth below.

A. *During what hours of the day and during what seasons of the year will observations with the University of Illinois radio telescope be required?*

The University of Illinois, supporter by Penn State, University of Michigan, National Radio Astronomy Observatory, Graduate Research Center of the Southwest, and the University of California, stated that the initial program ideally requires 24 hours per day, 365 days per year but that natural or man-made obstacles prevent that ideal from being realized. When the sun is at or near meridian, its radiation at 608-614 Mc/s is so strong that it obliterates extragalactic signals. High winds, ice storm and snow storms can create a

hazard to personnel normally making manual settings to the antennas at the Illinois observatory, thus delaying observations.

California and Michigan made the additional point relative to the need for freedom of access to the band by noting that the moon occasionally occults signals from certain sources. These occultations occur six to twelve times per year and offer a unique opportunity to obtain high effective angular resolution of the brightness and polarization distributions of the occulted source. This is done most satisfactorily in the general area of the UHF-TV band. Above this region, the thermal radio emission from the moon tends to mask the non-thermal radiation from radio sources, which decreases in intensity as frequency is increased, and uncertainty is introduced. Below this region, diffraction around the moon's limb reduces greatly the accuracy of the angular resolution of occultations.

B. What programs of research are currently planned for the University of Illinois radio telescope and what time schedules are involved?

The Universities of Illinois, Michigan, Alaska, California and Penn State and the NRAO replied to the effect that Illinois' initial program will consist of cataloging accurate positions and flux densities of signal sources. A five year program contemplates twelve to sixteen hours per day of interference-free observations. Under the Commission's proposal, respondents state that period, might be as little as four hours per day and it could require fifteen to twenty years to complete the program. Therefore, if any time limit is placed on the use of the channel for radio astronomy it should be twenty years rather than five.

Later programs, not defined at this time, would probably be general observing programs such as the initial program. There is no foreseeable time when the Illinois radio telescope would cease to perform a useful function.

C. What is the nature and importance of the results expected to be obtained from the programs referred to in B above?

Collectively, those responding to A and B above, anticipate the following results from the University of Illinois program:

1. determination of the flux density of individual sources;
2. more accurately established positions of individual sources;
3. determination of the character of emissions from different sources;
4. important information on the nature of the universe and of the nature of its expansion;
5. optical identification of extragalactic radio sources will be facilitated;
6. information that will help explain why one galaxy is an emitter and another is not; and
7. measurements of flux densities of radio sources on Channel 37 by the University of Illinois, coupled with similar measurements at other points in the United States and abroad, will provide additional information on the origin of high energy particle radiations in the universe.

Later programs are expected to throw light on possible variability of certain sources, their angular diameters and composite structure.

D. Could the program of research now planned for the University of Illinois radio telescope be carried out at any other existing facility?

The University of Illinois, supported by NRAO, Penn State and Michigan, stated that the question incorrectly assumes that observations are so few in number that programs can be switched from one instrument to another without a serious net loss in the amount of information obtained. The analogy is drawn between optical and radio telescopes, pointing out that the 200" telescope at Mt. Palomar can do all the 120" telescope at Lick Observatory can do, but that it would be absurd to suggest that the 120" can be abandoned in favor of the 200". Additionally, the University of Alaska stated that the Illinois radio telescope has the largest effective antenna reception area now in existence in the U.S., and all conclude that there is no alternative instrument in the U.S.

E. What is the minimum bandwidth within which protection is required for the University of Illinois radio telescope?

The consensus of the seven respondents to this point is that 6 Mc/s is the minimum bandwidth necessary to protect the Illinois telescope. This would provide a signal bandwidth of about 4 Mc/s with guard bands on either side. The broader the bandwidth, the more sensitive the instrument, with the sensitivity increasing as the square root of the bandwidth.

F. To what extent is it expected that radio signals originating on earth and reflected off the moon or man-made satellites will prove to be sources of interference to the University of Illinois radio telescope? How would such interference compare, in severity, with that generated directly by Channel 37 TV stations at various distances from the telescope?

The Graduate Research Center of the Southwest and Penn State took the position that an exclusive allocation to radio astronomy would be highly desirable because of inevitable reflections from aircraft, the moon and earth satellites if stations are transmitting in the band. The Universities of Illinois, Michigan and Alaska expressed the opinion that satellites such as ECHO would not create a serious problem due to their rapid motion.

The University of Illinois made reference to a report prepared by the Central Radio Propagation Laboratory (CRPL) of the Bureau of Standards, dated February 5, 1963, "Potential Interference from UHF Television Channel 37 to the Radio Astronomy Service" wherein calculations showed that a television station using Channel 37, on the Empire State Building, with an effective radiated power of 202 kW would result in a power of -191^1 dBW at the output terminals of the Illinois antenna approximately 5% of the time as a result of tropospheric scattering of the television signal. Since this level of signal is within the detection capability of the radio telescope, the respondent was of the opinion that nearly as many spurious sources would be recorded as real sources. It was anticipated that a television antenna 365' high at Paterson, N.J., with an ERP of 242 kW would produce similar results.

By comparison, power received as a result of reflection from the moon, where the moon is on the horizon with respect to the television station at Paterson, and randomly oriented with respect to Danville, would be -222 dBW and therefore not a threat to the radio telescope. On the other hand, if the moon were randomly oriented with respect to the television station, and in the main beam of the radio telescope, the power received would be -163 dBW and heavy interference would result. Under the latter conditions, observation of moon radiation at 610 Mc/s would be impossible.

11. SITC filed comments in reply to those of the University of Illinois, expressing the view that Illinois was inconsistent in its appraisal of the time required to complete its present program, in that the magazine article referred to in the Commission's Notice stated a need for five years of night-time hours, whereas the filing with the Commission indicated a need for 12 to 16 hours per day of actual observing time. SITC took exception to the assumptions used in the CRPL report referred to above. The CRPL calculations, while not detailed in the Illinois filing, were made available to SITC by Illinois. SITC contends that with very minor changes in the CRPL assumptions, it can be shown that interference will never be experienced at the Illinois radio telescope from a television station at Paterson. SITC further contended that the University of Illinois had not

¹ CCIR Report #224 (Geneva, 1963) deals with tolerable levels of interference for radio astronomy. It concludes that a sophisticated low-noise receiver at 840 Mc/s would suffer harmful interference in the presence of unwanted fields in excess of 0.017 microvolts/meter. It also indicates 7.9×10^{-10} W/m²/c/s, incident upon an isotropic antenna, as the tolerable level. This is equivalent to -251 dBW or -194 dBW for a 5 Mc/s bandwidth as used in the CRPL calculations. For receiving antenna gain G, the tolerable level becomes $(7.9 \times 10^{-10}) (10^{-0.25G})$ W/m²/c/s.

demonstrated that signals of sufficient intensity to cause interference would be present at the output terminals of the radio telescope. This contention is based on the fact that the radio telescope half-power beamwidth measured from the centerline of the main lobe covers only nine minutes of arc and operates at or close to zenith angles, whereas interference signals reaching the area by means of tropospheric scatter would be confined to low angles of arrival and hence discriminated against by the directivity of the radio telescope. Additionally, since the latter is located beneath the surface of the earth, it appears reasonable, in SITC's view, that some measure of terrain shielding would tend further to isolate the telescope from such interfering signals. SITC further argued that while Illinois claims interference would be received from the moon (-163 dBW) when the moon is in its main beam, Illinois does not show the probability of the existence of such a geometrical arrangement, which in fact could occur during the quiet hours specified for television stations in the Commission's proposal. SITC considered unrealistic the need for protection requested by Illinois when compared to the criteria used by the NRAO, Green Bank, West Virginia. Despite the fact that the NRAO antenna has a sensitivity approaching that of Illinois, NRAO requests only that no television stations operate within 150 miles of Green Bank on frequencies being observed by NRAO.

12. A number of pertinent comments were received, not related directly to the specific questions treated above. Carnegie Institution of Washington, National Science Foundation and the University of Illinois deplored the proposal to afford a protection period of only five years on the grounds that: 1) even though it proved sufficient to permit a cataloguing of discrete radio sources, it would not permit time in which to study things discovered during that period; 2) the life expectancy of the Illinois telescope is considerably in excess of five years, yet it would be afforded no protection after January 1, 1968; and 3) an instrument designed to meet a specific objective need not be abandoned when that project is completed.

13. As an indication of the degree to which Channel 37 would be used by astronomers, it is mentioned in the comments that the University of Illinois and Stanford University are now observing in that band; the Universities of California and Michigan as well as the Carnegie Institution of Washington have specific plans underway to use it; and the University of Pennsylvania will use it if made available to the radio astronomy service. While several other observatories were not specific as to future planning, their comments implied that observations would be conducted in the band if made available.

14. Dr. R. M. Fristrom, Johns Hopkins University Applied Physics Laboratory, commenting as an individual, suggested a compromise solution whereby radio astronomy and television might share time on Channel 37. He does not vouch for the practicality of his approach and suggests it be examined critically by workers in the field to ascertain whether it holds promise. Dr. Fristrom suggests that Channel 37 be exchanged for an unused educational TV channel wherever possible, making Channel 37 available for educational pur-

poses. A private foundation would then be established, sympathetic to radio astronomy's needs, to ensure a reasonable amount of public usage while minimizing interference to radio astronomy. In instances where no educational channel is available to trade for Channel 37, and it has been assigned to commercial interests, a private foundation might buy and operate the station, or buy advertising time and dedicate it as blank time to radio astronomy. He considers it important to operate one TV station experimentally on the channel to test compatibility techniques and to devise new ones. Under his plan, discrete segments of each hour could be designated as "quiet-time" or the radio astronomy observations could be interleaved in time with the TV transmissions. In the latter case, it is suggested that the TV signal be transmitted with a millisecond blank time at the end of each line—which might result in a signal degradation of about 10%. Also suggested is the blanking of alternate pictures or every other raster line, which respondent assumes will result in about a 50% degradation of the resolution. In either case, all radio astronomy observations within interference range of such a television station would have to be carefully synchronized with the television signal, and in either case the viewing public would be subjected to a seriously degraded picture. In the Commission's view, such an approach should be considered only as a last resort.

15. Of the remaining 100 or so comments filed in this proceeding, none raised a point or posed a question not contained in the formal filings identified by name in paragraph 5 above and, except for the broadcasting interests, were virtually unanimous in urging that Channel 37 be allocated permanently on an exclusive and nation-wide basis to the radio astronomy service. The University of Alaska, in supporting this position, pointed out that the space program requires knowledge of the particle and electromagnetic radiation pervading space at different times and places and that the radio astronomy service plays a major role in securing such information. The National Radio Astronomy Observatory expressed disbelief that Paterson, New Jersey needs a TV channel badly enough to jeopardize radio astronomy throughout the eastern United States when it is already served by many stations. In this connection, it is noted that no member of the general public in the Paterson area, or elsewhere, commented in favor of retaining Channel 37 for television.

16. Among the many filings in this proceeding, both from radio astronomers and the general public, a number of misconceptions have come to light. Among these are statements such as: (1) the FCC has taken Channel 37 away from radio astronomy and given it to commercial television; (2) * * * 608-614 Mc/s is at present the only remaining band in its octave not already assigned for use by transmitters and has been recommended for radio astronomy in the radio regulations * * *; (3) * * * the general need of radio astronomy for one clear channel per octave of the radio spectrum is known to the FCC. So far, two such channels have been provided in the U.S., namely, 404-410 Mc/s and 1400-1427 Mc/s * * *; (4) European broadcasters have been excluded from the use of the band 606-614

Mc/s; (5) * * * at the Stockholm Conference of a year ago, the European authorities agreed to keep the over-lapping two channels in this region as clear as possible for radio astronomy use * * * (6) * * * the Geneva Conference, 1959, adopted a substantial measure of protection for 606–614 Mc/c which has led internationally to considerable progress * * *; and (7) * * * the FCC Docket suggests an appalling lack of comprehension within the FCC of the nature and needs of radio astronomy and yet the Commission has power to cripple and perhaps even destroy radio astronomy. We comment on these matters below, in the interest of clarification.

17. (1) The UHF-TV band, 470–890 Mc/s, consisting of Channels 14 through 83, has been allocated exclusively for television broadcasting since April 11, 1952, and no portion thereof has ever been allocated to the radio astronomy service within the United States.

(2) As of July 29, 1963, no authorizations had been granted and no applications were on file with the Commission for Channels 54, 60 or 68, representing the frequency bands 710–716 Mc/s, 746–752 Mc/s and 794–800 Mc/s, respectively.²

(3) Since October 1961, as reflected in Part 2 of the Commission's Rules, the following frequency bands have been allocated exclusively to the radio astronomy service on a nation-wide basis:

40.66–40.70 Mc/s	10680–10700 Mc/s
73.0–74.6	15350–15400
1400–1427	19300–19400
2690–2700	31300–31500
4990–5000	

On that same date, the following additional frequency bands were allocated to the radio astronomy service on a secondary basis:

2495–2505 kc/s	14990–15010 kc/s
4995–5005	19990–20010
9995–10005	24.99–25.01 Mc/s
	404–406 Mc/s

18. Items (4), (5), (6) and (7) of paragraph 15 are best treated in a chronological discussion of how the United States arrived at its present posture, insofar as frequency allocations to the radio astronomy service are concerned. Although radio astronomy got its start in 1937 through the work of Karl Jansky, it was not until 1955 that any official action was initiated in the United States to cater to the frequency requirements of that budding science. Becoming aware of the upsurge of interest in radio astronomy, in early 1955 the Commission issued a public notice soliciting the views of radio astronomers relative to their frequency needs. Simultaneously, similar action was taken by the Interdepartment Radio Advisory Committee (IRAC) to ascertain the frequency requirements of various government agencies in support of radio astronomy. Although an appreciable number of replies to each inquiry were received, there was virtually no correlation in stated requirements between any two replies. The stated needs were so diverse as to preclude any realistic reallocation of the

² There appears no prospect of clearing these bands world-wide for radio astronomy, and they are not now being observed in the United States.

spectrum to accommodate them. Something approaching a total of 4000 Mc/s of spectrum space would have been required to satisfy what amounted to individual, randomly-selected and unrelated bands throughout the spectrum.

19. Following a series of discussions and exchanges of correspondence with Associated Universities, Inc., and after consultation with the IRAC, the Commission adopted a Notice of Proposed Rule Making in Docket No. 11745 on June 20, 1956 looking toward the establishment of a protected zone around the newly-established National Radio Astronomy Observatory at Green Bank, West Virginia and the Naval Radio Research Observatory at Sugar Grove, West Virginia. Comments in response to that Notice resulted in the adoption of a further Notice of Proposed Rule Making on June 5, 1958 in the same Docket. Subsequently, on November 19, 1958, the Commission issued a Report and Order in this Docket amending Parts 3, 4, 5, 6, 7, 9, 10, 11, 16, 20, and 21 of its Rules to stipulate the following concept in each:

In order to minimize possible harmful interference at the National Radio Astronomy Observatory site located at Green Bank, Pocahontas County, West Virginia, and at the Naval Radio Research Observatory site at Sugar Grove, Pendleton County, West Virginia, any applicant for a station authorization other than mobile, temporary base, temporary fixed, Citizens Radio, Civil Air Patrol, or Amateur seeking a station license for a new station, a construction permit to construct a new station or to modify an existing station license in a manner which would change either the frequency, power, antenna height or directivity, or location of such a station within the area bounded by 39°15' N on the north, 78°30' W on the east, 37°30' N on the south and 80°30' W on the west shall, at the time of filing such application with the Commission, simultaneously notify the Director, National Radio Astronomy Observatory, P.O. Box #2, Green Bank, West Virginia, in writing, of the technical particulars of the proposed station. Such notification shall include the geographical coordinates of the antenna, antenna height, antenna directivity if any, proposed frequency, type of emission, and power. In addition, the applicant shall indicate in his application to the Commission the date notification was made to the Observatory. After receipt of such applications, the Commission will allow a period of twenty (20) days for comments or objections in response to the notifications indicated. If an objection to the proposed operation is received during the twenty day period from the National Radio Astronomy Observatory for itself or on behalf of the Naval Radio Research Observatory, the Commission will consider all aspects of the problem and take whatever action is deemed appropriate.

Through this action, and parallel action by the IRAC with respect to government operations, a "quiet zone" extending approximately 100 miles on each side and embracing the entire radio spectrum was established to protect radio astronomy observations at Green Bank and Sugar Grove, W. Va.

20. The International Radio Consultative Committee (CCIR) is one of the permanent organs of the International Telecommunication Union (ITU) and normally holds Plenary Assemblies at three year intervals. Recommendations and Reports adopted by such assemblies serve as technical bases upon which subsequent Administrative Radio Conferences can develop changes in the international Table of Frequency Allocations in the event other considerations indicate a change is warranted. The IXth Plenary Assembly of the C.C.I.R. (Los An-

geles, April 1959) adopted Recommendation No. 314 pointing out the basic needs of radio astronomy, i.e., bands in which spectral line radiations could be observed and those in which continuum observations could be made. Spectral lines are characteristic of specific elements and represent their natural periods of oscillation, and hence the frequencies at which such radiations appear in the radio spectrum. Spectral lines are dictated by nature and offer the frequency allocator no choice except in the width of the band which might be reserved for the study of the spectral line. Continuum observations, on the other hand, may be conducted in any part of the radio spectrum, but, in order to get the best sampling of data, should be conducted in a series of bands having octave relationships throughout the spectrum. The specific spectral lines and associated bandwidths for which complete international protection was recommended by the C.C.I.R. are as follows:

deuterium 327.4 Mc/s (322-329 Mc/s)
 hydrogen 1420.4 (1400-1427 Mc/s)
 OH radical 1667 (1645-1675 Mc/s)

Of the three, only radiations from monatomic hydrogen have ever been detected in nature. The bands suggested for continuum studies in Recommendation No. 314 were 40, 80, 160, 640, 2560, 5120 and 10240 Mc/s, with over-all bandwidths increasing from a minimum of 1.5 Mc/s to 20 Mc/s. It will be noted that insertion of the deuterium and hydrogen bands into the list of continuum bands would complete the octave or approximate harmonic relationship of the total list.

21. Subsequent to the IXth Plenary Assembly, Recommendation No. 314 was considered by the ITU Administrative Radio Conference (August-December, 1959) to determine the extent to which radio astronomy could be accommodated. Because of a number of factors, most important of which was spectrum occupancy due to existing radio services, the radio astronomy service was afforded allocation status in only one band, 1400-1427 Mc/. By footnotes to the international Table, the following bands were made available to radio astronomy on a world-wide basis without rights of protection from those services having allocation status in the body of the Table itself: 2690-2700 Mc/, 4990-5000 Mc/s, 10680-10700 Mc/s, 15350-15400 Mc/s, 19300-19400 Mc/s and 31300-31500 Mc/s. Below 1000 Mc/s, however, it was not possible for the Conference to reach agreement on a world-wide basis and only Regional provisions could be agreed for radio astronomy. For example, Recommendation No. 32 of the Conference recommended that administrations, in preparing for the next Administrative Radio Conference, give consideration to the possibility of making an allocation in the range 37-41 Mc/s and in the meantime avoid, as far as practicable, assigning transmitting stations at 38 and 40.68 Mc/s \pm 0.25 Mc/s. In ITU Region 2 (the Americas) 73-74.6 Mc/s was made available by footnote, whereas the remaining two Regions gave the radio astronomy service footnote status in the band 79.75-80.25 Mc/s. Region 1 (European and African areas) made 150-153 Mc/s available by footnote but the rest of the world could not accommodate radio astronomy anywhere in this part of the spec-

trum. Something approaching unanimity was achieved in footnote No. 317 wherein 404-410 Mc/s was made available in Regions 2 and 3 and 406-410 Mc/s was made available in Region 1.

22. Finally, with regard to the band 608-614 Mc/s, footnote No. 332 provides that:

In Regions 1 and 3, the band 606-614 Mc/s may be used by the radio astronomy service until such time as it is required for use by other services to which this band is allocated. During this period administrations should take all practicable measures to avoid harmful interference to radio astronomy observations.

23. Additionally, a European VHF/UHF Broadcasting Conference was convened in Stockholm, Sweden in 1961, under the auspices of the ITU, to devise an allotment plan whereby the broadcasting needs of the countries concerned could best be met with a minimum of interference to other countries and to themselves. Recommendation 2, adopted by that Conference, recommends that

Administrations should continue to comply, as far as practicable, with a request made by the Inter-Union Committee on the Allocation of Frequencies for Radio Astronomy and Space Science (I.U.C.A.F.) to avoid the use of Channel No. 38 (606-614 Mc/s) in the development of their UHF broadcasting services.

Despite the adoption of that Recommendation however, the Conference allotted the channel for use by the broadcasting service in a total of 41 cities in 14 different countries. Records available to the Commission show that the channel is now in use for broadcasting at three locations in Germany and two locations in the USSR. Additionally, records indicate that Italy is using portions of the same band at three locations for point-to-point operations.

24. In April 1963, a VHF/UHF African Broadcasting Conference was convened in Geneva for the same basis purpose as the Stockholm Conference. The results of that Conference, as they pertain to Channel 37 (Channel 38 in ITU Region 1), and as reported in *Telecommunication Journal*, July 1963, are as follows:

* * * At an earlier stage it was decided to protect the radio astronomy service at least to the extent to which it was protected in the Stockholm Agreement. In the Stockholm Agreement the use of Channel 38 which coincides with band 606-614 Mc/s used in radio astronomy, was to be avoided "as far as practicable." When bands IV and V were being considered in the Plenary session, this matter was again discussed. By this time, several countries had included Channel 38 transmissions in their plans. Since radio astronomy is of vital importance to the world and that no infallible method exists of providing protection in this service if terrestrial emissions take place, the case of Channel 38 was reopened. At this point the delegation with the largest number of Channel 38 stations intervened and announced a dramatic modification—their deletion of all proposed use of Channel 38. This action was greeted with spontaneous acclamation, as was the announcement by successive delegations that Channel 38 would not be used for television * * *

25. The Channel 37 problem first arose in the United States when, on May 6, 1960, the University of Illinois filed with the Commission a petition for rule-making requesting the re-allocation of Channel 37 (608-614 Mc/s)³ from television broadcasting to radio astronomy on a national basis. The petitioner stated that construction of the

³ Channel 37 in the U.S. corresponds, in part, to Channel 38 in Europe.

telescope was under way near Danville, Illinois under a contract with the Office of Naval Research. The design frequency had by then been selected and construction initiated in the hope and anticipation that 610-615 Mc/s would be reserved for radio astronomy by the Geneva Conference (1959) as part of a proposal advanced by the Netherlands which was not supported by the United States or other countries in Region 2. On March 8, 1961, the Commission adopted a Memorandum Opinion and Order denying the University of Illinois petition. On April 11, 1961, the University of Illinois filed a Petition for Reconsideration and shortly thereafter asked, by letter, that the petition be held in abeyance pending disposition of the proceedings in Docket No. 11997 and that the petition be taken into consideration in that proceeding.

26. Assertions charging the Commission with a lack of comprehension of the nature and needs of radio astronomy and implications that the Commission might cripple and even destroy radio astronomy are unjustified and can not be supported by facts. Whereas the existing international Radio Regulations afford radio astronomy only footnote status in all bands other than 1400-1427 Mc/s, as described in paragraph 20, it will be noted in paragraph 16 that virtually all of those bands have been afforded allocation status in the United States. That improved position is a direct result of actions initiated by the Commission, on its own motion, in consultation with the Office of Emergency Planning and the IRAC. Further, the proposals of the United States to the Extraordinary Administrative Radio Conference to be convened in Geneva on October 7, 1963 to deal with frequency allocations for space radiocommunication and radio astronomy, recommend that the following bands be allocated to the radio astronomy service on a world-wide exclusive basis:

1400-1427 Mc/s	15350-15400 Mc/s
2590-2600	19300-19400
4990-5000	31300-31500
10680-10700	

Under those same proposals, 73.0-74.6 Mc/s would be allocated exclusively to radio astronomy in Region 2, 402-404 Mc/s would be allocated world-wide on a shared basis with meteorological aids, and 1664.4-1668.4 Mc/s on a world-wide basis with meteorological satellites. In the last two cases, radio astronomy would be afforded secondary status.

DECISION

27. Returning to the matter at hand, the comments submitted in this proceeding and all other information available to the Commission support the following findings and conclusions:

(a) Data which are of significant scientific value, and which may be of importance in the nation's space program, can be obtained through radio astronomy observations in the UHF TV portion of the radio spectrum under the present state of the art.

(b) Obtaining certain of these data depends upon observations in the same frequency band over extended geographical areas.

39 F.C.C.

(c) The only prospect for world-wide clearance of frequencies for radio astronomy in this portion of the spectrum is in the band 608-614 Mc/s.

(d) Considering only the University of Illinois observatory, and in view of the necessary protection level cited previously on CCIR Report #224, there is doubt as to the adequacy of a protected radius in the order of 600 miles. It is probable that Channel 37 operations at Paterson, New Jersey would interfere with observations at Danville to a certain extent. Also, (since interference from different sources would probably not occur simultaneously) the situation would be complicated by interference from other Channel 37 stations if authorized. Moreover, any interference which would exist, even though for only a small percentage of time, might occur at critical times in the observing process. To the extent that observation programs would be interfered with, the time of completing them might well be substantially increased, so that a longer period of protection would be required to achieve the same results.

(e) Activation of the Illinois radio telescope will not obviate the need for additional observations in different programs in the band 608-614 Mc/s at other locations in the United States, particularly in view of the fixed nature of the Illinois radio telescope. It appears that observations at other points will be made and that adequate interference protection should be afforded to radio astronomy observations in the band 608-614 Mc/s throughout the United States rather than to the Danville site alone.

28. The Commission is also persuaded by the comments filed that a five year period would be insufficient to meet the needs of radio astronomy in general in this portion of the spectrum. While perhaps adequate for initial programs, it would not permit a protected period during which initial discoveries could be explored further. It would also be insufficient to justify the installation of additional equipment at observatories other than Danville, Illinois. On the other hand, it cannot be concluded from the facts at hand that a permanent reservation for this service and withdrawal of the band for television, is justified. The Commission has concluded that a period of 10 years should be adequate to meet the needs of radio astronomy and justify the installation of observing equipment. In the interim, the matter will be subject to periodic review to determine whether the protected status should be maintained or whether Channel 37 should revert in whole or in part, to the television broadcasting service.

29. Failure to provide adequate protection to radio astronomy in this portion of the spectrum may do irreparable harm to the cause of scientific development. Therefore, the Commission concludes it would be in the public interest to make Channel 37 available to radio astronomy, by footnote to the Table, on a nation-wide basis for a ten-year period during which Channel 37 will not be assigned to any television broadcasting station. Further, it is the Commission's intention: 1) to solicit the cooperation of Canada and Mexico in taking similar action in those countries; and 2) to initiate action looking toward modification of the USA proposals to the Space Conference in October, to

recommend that this channel be reserved for radio astronomy on a world-wide basis for a ten-year period.

30. We recognize that the showing made in support of a nation-wide Channel 37 reservation for radio astronomy has some limitations, and there is some merit in the broadcaster's arguments. Nevertheless, it must be borne in mind that inevitably a showing with respect to this new science, its needs and potential, must at this point be somewhat speculative in nature. In view of the united interest of the scientific community in such a reservation, and the vast potential offered by radio astronomy for adding significantly to our knowledge of the universe, we do not believe it to be in the public interest to close the door on, or even jeopardize, whatever benefits may be derived from such operations, at Danville and elsewhere, by failing to afford them temporary nation-wide protection in the 608-614 Mc/s band, which is the one appearing most feasible for international agreement on this use.

31. In providing for a ten-year reservation and withdrawal from television, we have of course weighed the loss in potential TV service, both specifically at Paterson, New Jersey (and Melbourne, Florida, where another application for the channel is pending) and, in general, in terms of total existing and potential assignments. Section 3.606 presently contains slightly more than 15 Channel 37 assignments, and the staff's recent UHF allocation studies indicate that about 30 assignments per channel can be made in the 48 conterminous states. On the basis of applications presently on hand we would be able to satisfy the requirements of those cities wherein Channel 37 would otherwise be available. However, if the usage of the UHF TV band grows as anticipated, the satisfaction of such needs will become increasingly difficult and, in some areas, impossible. To the extent that these Channel 37 requests are satisfied by replacements drawn from another area, there will of course be a net loss to the area from which the replacement is withdrawn. It appears highly unlikely that any viewers will lose the only service they would otherwise have available. At Paterson, for example, we are proposing a specific replacement for Channel 37 in the new UHF Table. To the extent that real losses in potential are involved, we believe the loss is outweighed by the potential gain accruing through the advancement of science.

We mentioned above, and wish to re-emphasize, that the Commission is not by this action permanently withdrawing Channel 37 for the broadcast service. Accordingly, in the Table of Assignments we will continue to list Channel 37 assignments, with a note indicating that they will not be available for use until after January 1, 1974.

33. In commenting on the bandwidth required for a radio-telescope in this portion of the spectrum, one respondent stated " * * * it is to be strongly recommended that TV stations on adjacent channels be placed as far from the radio telescope as possible because of the danger of spurious radiation interference * * * ". In this connection, it must be made quite clear that the Commission has no intention of placing any constraints upon the use of Channels 36 and 38 apart

from those now applicable to all other UHF-TV channels in Part 3 of the Rules. This absence of constraints includes complete freedom to modify the Table of Assignments as necessary in the public interest. Also pertinent to this point is the matter of radiation from oscillators in television receivers and the possibility of interference to radio astronomy observations resulting therefrom. As an example, the radiation from television tuned to Channel 30 would fall within Channel 37. Therefore, practical observations on Channel 37 would be precluded in areas reasonably close to a television station operating on Channel 30 because of the cumulative effect of a number of receivers tuned to that channel. The practical answer to the problem of adjacent channel operation as well as the receiver radiation problem is the establishment of radio astronomy observatories in remote areas, well removed from centers of population density. Location of Channel 37 observatories should of course take into account all UHF-TV channel assignments provided in our present and proposed Table.

34. Although most comments failed to mention the subject of adjacent channel interference, the potential magnitude of the problem should be brought to the attention of the radio astronomy community since it will tend to limit the usefulness of Channel 37 for radio astronomy in many areas of the country. For example, according to information filed with the Commission in Docket No. 11654 by the Electronic Industries Association (EIA), a typical television visual transmitter has a radiated spectrum signature at the lower channel edge which is 50 db below the peak visual power in a 0.1 Mc/s bandwidth. This typical signature is 75 db down at the center of both the upper and lower adjacent channels. If the 20 db vestigial sideband filters were removed it is reasonable to assume that the radiated power at the lower channel edge would be 30 db below the peak visual power in a 0.1 Mc/s bandwidth. Section 3.687 of the Commission's Rules permits a 1 kW visual transmitter operating on Channels 15-83 to have an amplitude characteristic exhibiting no attenuation at the lower channel edge and 20 db attenuation at the upper channel edge. With antenna gains on the order of 15 db, a UHF-TV transmitter on Channel 36 or 38 could legally radiate appreciable power well into Channel 37. In practice, however, most of the power radiated by a TV visual transmitter (with the exception of the color subcarrier) is within 1 megacycle of the visual carrier frequency. In addition to remotely located observatories, the problem of adjacent channel interference can be minimized by observing in that portion of Channel 37 farthest removed from the interfering signal, i.e., 608-611 or 608-612 Mc/s to avoid Channel 38 and 610-614 or 611-614 Mc/s to avoid Channel 36.

35. The specific rule changes necessary to carry out the Commission's decision, authority for which is contained in Section 4(i) and 303 of the Communications Act of 1934, as amended, are found in the Appendix hereto.

36. *It is ordered*, That the proceedings in this docket are terminated and *It is further ordered*, That effective November 15, 1963,

Parts 2 and 3 of the Commission's Rules *Are amended* as set forth in the Appendix hereto.

APPENDIX

1. Section 2.106 is amended by adding a new footnote NG48 designator in Column 7, in the frequency band 470-890 Mc/s, and by adding a new footnote as follows:

§ 2.106 Table of Frequency Allocations.

* * * * *

NG48 Stations in the broadcasting service will not be authorized in the band 608-614 Mc/s prior to January 1, 1974. In the interim the band is available for use by the radio astronomy service. The radio astronomy service shall be protected from extraband radiation only to the extent that offending stations are required to comply with the technical standards applicable to the service in which they operate.

2. Section 3.603 is amended by adding a new paragraph (c) as follows:

§ 3.603 Numerical designation of television channels.

* * * * *

(c) Channel 37, 608-614 Mc/s, is not available for assignment prior to January 1, 1974.

DISSENTING STATEMENT OF COMMISSIONER ROBERT E. LEE
IN WHICH COMMISSIONER KENNETH A. COX JOINS

I dissent to the Commission's action whereby it has reserved UHF TV Channel 37 for radio astronomy, thereby denying access to the channel to broadcasting for ten years—and perhaps forever.

I am totally sympathetic to the necessity for the advancement of science and our research into the vast unknown. Were I not, I would not have dedicated so much of my energy to the cause of educational television, the medium that holds such great potential in massive education and in the stimulation of scientific endeavor.

There appears to be an attitude in some circles that television broadcasting is (1) an entertainment medium; (2) a commercial bonanza; and (3) a waste of spectrum space. If television broadcasting were to be judged by much of what currently appears on TV screens and the fact that there are currently idle many UHF channel assignments, perhaps I could agree. However, these criteria do not afford a fair evaluation of a proper allocation of spectrum space among the various radio services. If science cares to perpetuate itself and make itself attractive to coming generations, it will see to it that the use to which television is put is not wasteful, but rather contributory to an enlightenment of the public.

A brief description of events is in order. The FCC allocated 70 channels to UHF broadcasting in 1952. This allocation had world-wide acceptance and many European countries are proceeding at even a greater pace than ours to install television facilities in these bands. Apparently it is the surge of interest, in this and foreign countries, to utilize the bands of frequencies duly allocated for television broadcasting that has prompted consternation among those who would like to inhibit UHF television and to divert these frequencies to other uses. Several countries have supported the world-wide exclusive allocation of Channel 37 for radio astronomy. These countries, being

smaller than our own in area and population, apparently have little foreseeable need for as many as 70 UHF television channels. This lack of equivalent need for a multiplicity of television stations is partly manifested by the wider bandwidth that each European television station occupies. Thus, the wide use of the UHF band for television broadcasting may be regarded as somewhat of a luxury by many foreign countries. It is with this philosophy that we are asked to join and in this atmosphere that we, the United States, must meet in international conferences.

Whether a calculated judgment or a disregard of radio allocations was the factor which led the University of Illinois to choose Channel 37 for an investment in the installation of a radio telescope in Danville, Illinois, is difficult to ascertain. Only a university, certainly not a commercial enterprise or a government entity, could have come out so favorably.

The Congress of the United States made a provision in the Communications Act which prohibits our agency from licensing a radio installation which is not first authorized by the FCC. This provision is a wise one, designed to prevent a *fait accompli*. In order that a station be licensed, there must be a prior finding by the Commission that the operation proposed will serve the public interest. But the Congress certainly could not have contemplated that radio astronomy interests would build multi-million dollar non-emitting installations throughout the radio spectrum and then exact from the Commission protection against the very radio users to whom the bands are assigned. I firmly believe that this unanticipated loophole in the Communications Act must be plugged to prevent a repetition of these circumstances which the Commission has faced here.

The Commission's Report and Order would place a time limit on the diversion of Channel 37. However, the ten-year limitation on the radio silence which the Commission has adopted gives me little solace. I am positive that the FCC of the future, the men who replace us, will find it even more difficult to deny the arguments advanced by radio astronomers for continued use of Channel 37 than we find today. It is quite clear from this record that radio astronomers want *time* to study that which will have been discovered. In this science, space is measured in terms of light years and time is measured in milleniums.

Were this use of Channel 37 to be the only effective means of space exploration, I might find little difficulty in joining the majority. However, such is not the case. The astronomers have sought and obtained radio windows throughout the spectrum. They assert that it would be desirable to have a window at every octave of frequency. At present the closest channel provided for radio astronomy to that sought here is at 400 megacycles. By the action herein the Commission has also created a pseudo short-term window at 600 megacycles not an octave but only 200 megacycles away. An octave would occur at 800 mc. Yet we have already provided a window at 1400 mc. This spacing between 400 mc and 1400 mc is not ideal, perhaps, but I have not been able to determine from the comments in this proceeding how

far this arrangement deviates from the ideal nor can I determine how important it is to achieve the ideal. Hence, I am unable to determine the extent to which the investment of capital at Danville, Illinois, has provided a useful or necessary new window for astronomers in the middle of the television broadcast band. For this and reasons that follow, I have little to satisfy my fear that the Commission may not have committed a vain act.

There are other factors which tend to contribute to interference to this installation, some of which may be attributed to radio emissions and some which may not. The ambient radio frequency noise levels in large areas of the United States are already high and increasing yearly. Emissions from electrical devices, which are beginning to clutter the spectrum, have plagued users for many years. The source of these emissions are well known to the radio listeners who have tried vainly to find enjoyment from their AM car radios or have been disturbed by neighboring electric razors. The Commission has, at present, authority only over the *use* of devices which may cause interference. Hence, preserving the air waves from gradual degradation has been a most difficult task for the Commission which I hope Congress will soon rectify by giving us broadened authority. Electrical noise is a problem of such magnitude that it requires the Commission's and other government monitoring installations to be located in remote areas and to move when population growth dictates. I hope, but I cannot be confident from the record before me, that the potential source of interference from nonlicensed devices has been taken carefully into consideration.

However, there are other possible sources of electrical interference to Channel 37 observations at Danville which may develop to nullify the charitable intent of the Commission. The amount of radio energy which Channel 36 and Channel 38 stations may pour into Danville may not be inconsiderable nor may the energy of the local oscillators of television receivers tuned to Channel 30. Moreover, harmonic radiation from other radio users, even when attenuated in accordance with good engineering practice, will, no doubt, be a source of serious interference in populous areas such as Eastern Illinois. From this record I can only *hope* that all goes well at Danville.

I cannot display the confidence of the majority of the Commission that its action will be effective, contributory to the scientific world and hence in the public interest.

I trust too that this action will not be taken as a tribute to those who jump first and look afterward.