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Glaser

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NONIONIZING RADIATION IN THE ENVIRONMENT

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MR. DAVID JANES: I will talk to you this morning about nonionizing radiation in the environment. Not more than about fifty years ago one could observe antenna wires stretched from houses to other structures to bring signals from distant radio stations into so-called wireless receiving sets. As the power of the broadcasting stations increased, as towns established local stations, and as the receivers improved, the antenna wires disappeared. With World War II came the demand for vast communication networks and the development of a new and expanded technology which was nurtured by theoretical and applied science and accompanied by a new engineering and industrial giant, the electronics industry. The industry's roots were found in the work of Maxwell and Hertz in the last half of the nineteenth century and in the later experimental work of Marconi and others.

The first regular broadcasting license was issued to Radio Station KDKA, Pittsburgh, in 1921. By 1927 the Federal Radio Commission was established to straighten out the confusion caused by 732 broadcasting stations in regular operation. The same year the Bell Telephone Laboratories sent the first television picture by wire. Secretary of Commerce, Herbert Hoover, participated in this transmission between New York and Washington. Ten years later 17 experimental TV stations were in operation, and in 1940 a construction permit was issued for the first FM radio station[1].

All radio construction stopped during World War II, but the demands for wartime communications spurred the development of the electronics industry. Immediately after the war electronics technology converted to civilian consumer products and arrays of new antennas began appearing. Applications for licenses for radio and TV stations mushroomed during the post-war years, and TV and radio became a prime source of news and entertainment to a growing U.S. population. In 1945, the first commercial communications using microwaves were established between New York and Philadelphia. Microwave communications stations now number over 71,000[2]. Devices employing microwaves, including radar, have become key segments in our communications networks.

As with many other advances, the electronics communication industry has not expanded without introducing associated problems. The radiation that is broadcast by communications stations strikes nearly everyone nearly all the time. In these broadcasts the sound or picture message is converted into electrical impulses which are greatly amplified at the transmission station before being put on carrier waves assigned to each station. The Federal Communications

Commission licenses each nongovernment station to operate within a particular wavelength or frequency and power output limits. The carrier waves are part of the electromagnetic spectrum.

As shown in Figure 1, ionizing radiation, which we usually deal with, falls toward the high-energy end of the spectrum. The so-called nonionizing radiation falls in the medium frequency range, which contains the A, broadcast band, and the VHF and UHF bands which contain FM, all of our television, and most of the microwave frequencies. Microwaves also run into the extra-high frequency range.

High energy radiations are known to be harmful. Deleterious effects of exposure to microwaves and radio-frequency radiation at high power densities have also been noted. Some investigators have described less definite effects, including psychological disturbances, at lower power densities[3]. In contrast to the delivery of many radiations, however, the waves used in communications are purposely aimed at receiving sets which are also in the proximity of people. We, therefore, have a situation where an increasing number of people are purposely being exposed to increasing amounts of radiation.

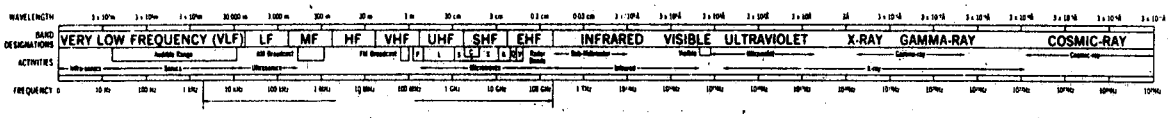
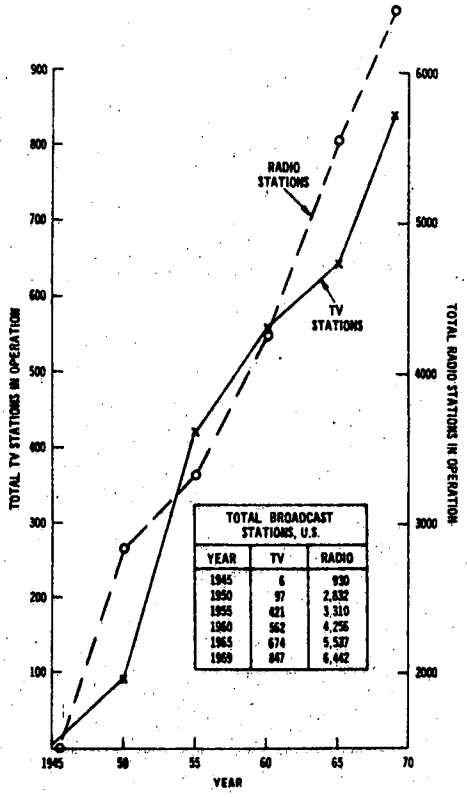


Figure 1. Electromagnetic spectrum showing band designations and activities at various wavelengths and frequencies.

Figure 2 shows the number of TV and radio stations in operation in the United States since 1945[1]. The ordinate on the left gives the total number of TV stations up to 1969. The ordinate on the right shows the number of AM and FM radio stations. The FCC as of February 1, 1971 listed 892 TV stations and 7,868 broadcasting stations[4].

Figure 3 indicates that the population of this country is growing as communications grow[5]. More properly put, the communications industry is growing as the populations grow. There is a demand which is association with population.

Figure 4 shows the distribution of microwave and unclassified radar stations in the United States.



TOTAL BROADCAST STATIONS, U.S.

YEAR	TV	RADIO
1945	6	930
1950	97	2,832
1955	421	3,310
1960	562	4,255
1965	674	5,537
1969	847	6,442

Figure 2. Increase in radio and TV stations in the United States from 1945 through 1969.

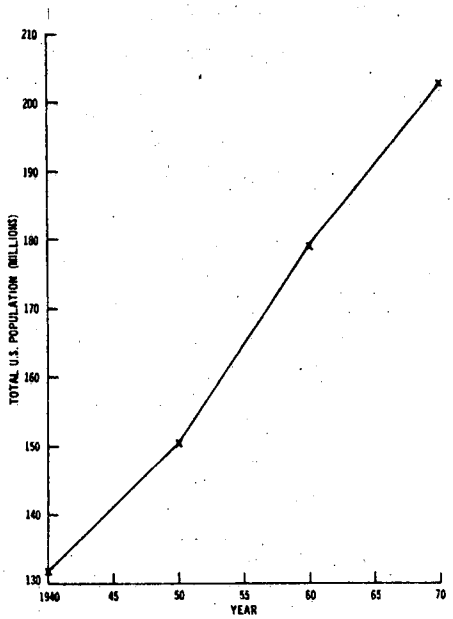


Figure 3. U.S. population growth since 1940.

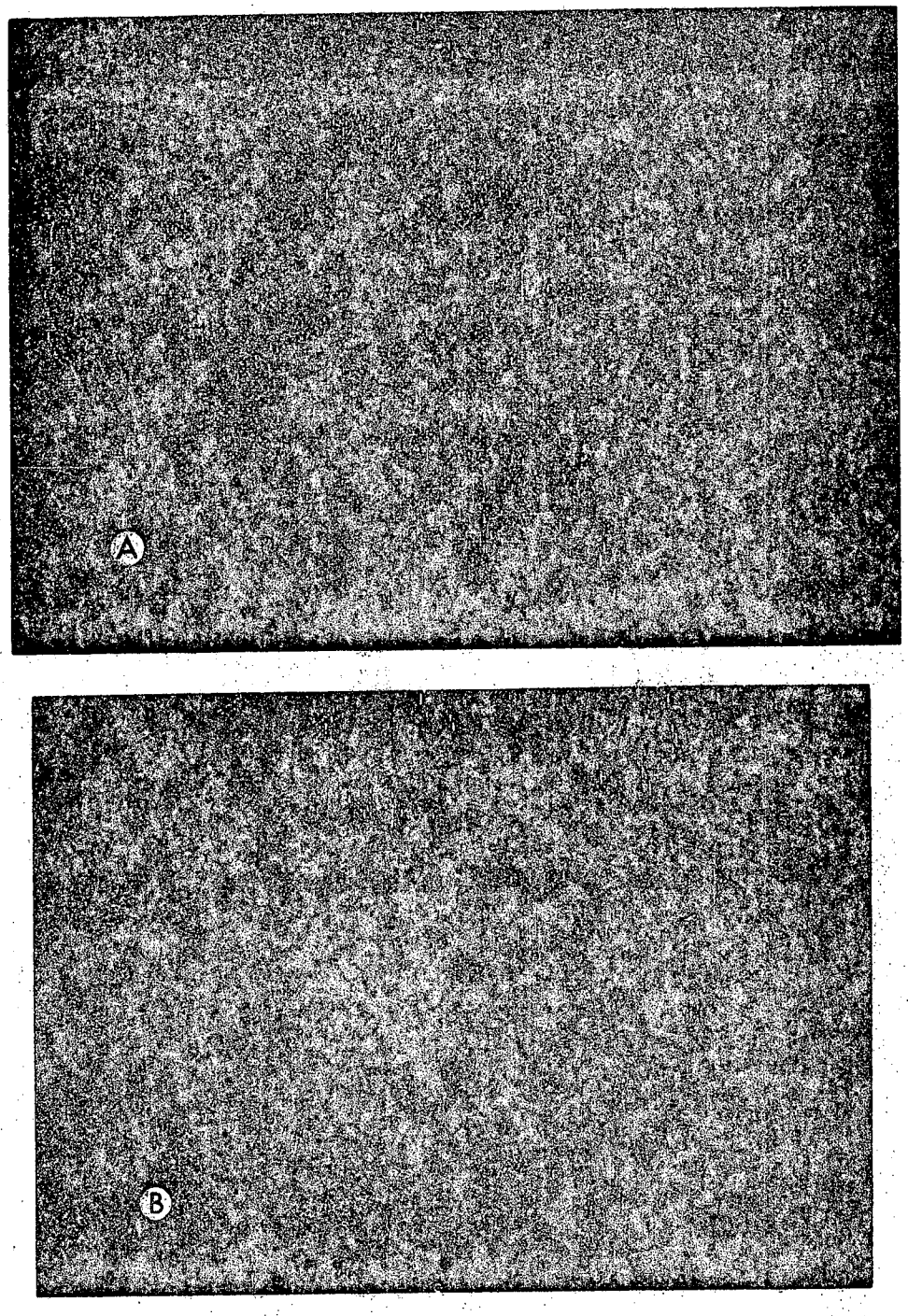


Figure 4. Distribution of (A) microwave and (B) radar stations in the U.S. This information was supplied by the Electromagnetic Compatibility Analysis Center in May 1971.

Figure 5 presents the number density of the AM, FM, and TV stations in the United States. Collectively these resemble a number density map of the population of this country. The point I would like to bring out is that the transmitters and consequently the greatest exposure is where the people are.

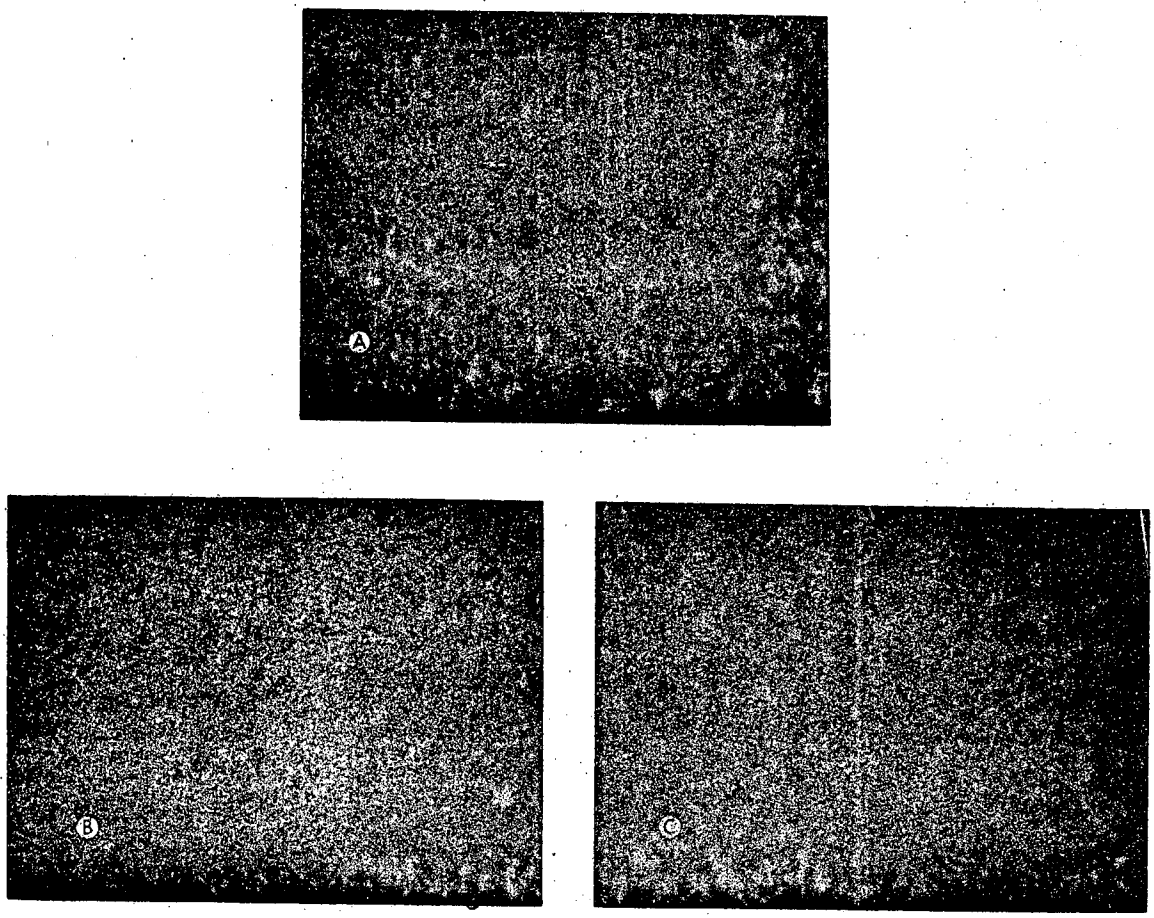


Figure 5. Distribution of (A) AM, (B) FM, and (C) TV broadcast stations in the United States. This information was supplied by the Electromagnetic Compatibility Analysis Center in May 1971.

Figure 6 shows the number of broadcast and microwave sources together with the population by Public Health Service region. The number of broadcast sources includes the entire band, AF-FM radio, television, and presumably two-way fixed radios since the number of broadcast stations totals about 16,000[2]. The dotted bars indicate the number of broadcast stations, the open bars the number of microwave relay stations superposed on the number of radar stations, and the cross-hatched bars the population. In general, the sources match the population.

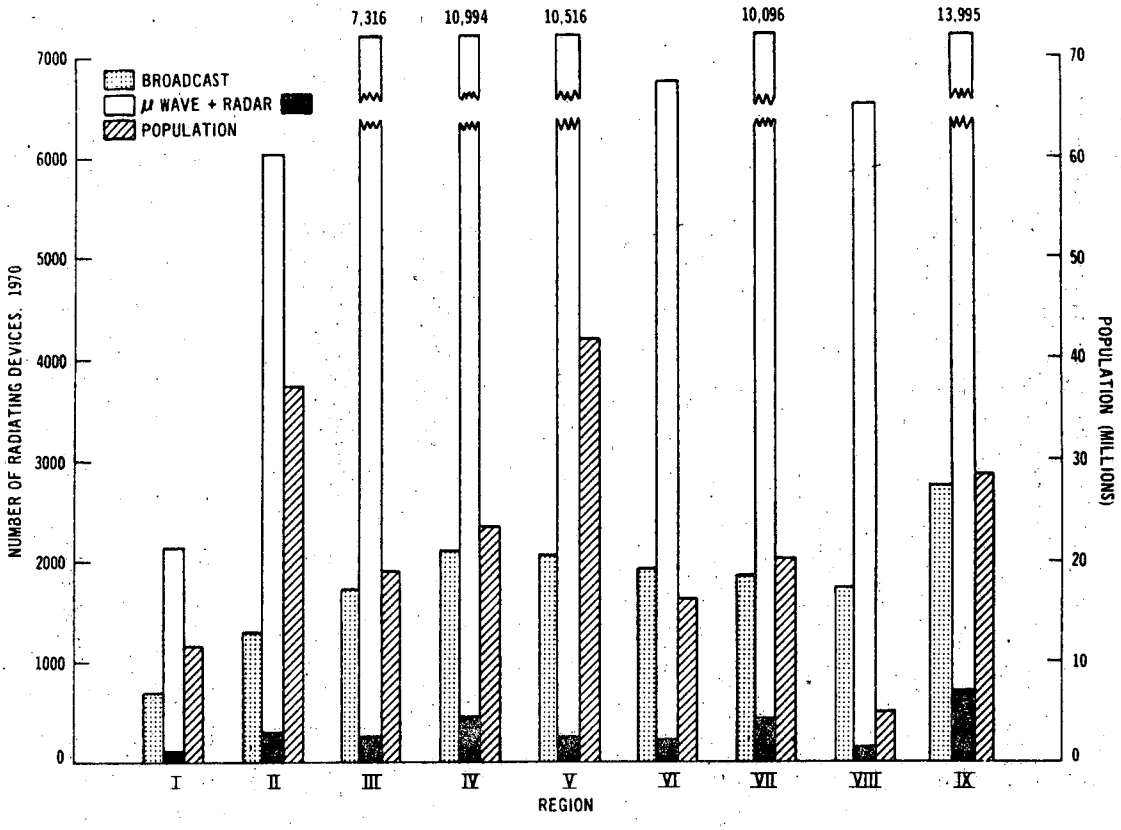


Figure 6. Regional distribution of broadcast, microwave plus radar stations, and population.

Figure 7 depicts number of stations, total power, and population for some selected large metropolitan areas of the United States. There are some exceptions, but, in general, there is exposure where there are concentrations of people. Total powers were obtained simply by adding the power output of AM, FM, and TV transmitters within the area[6,7]. Obviously this determination could be made for any locale. Although we are not certain at this time how meaningful the number is, compilations of this nature may be useful in identifying populations that receive the greatest exposures.

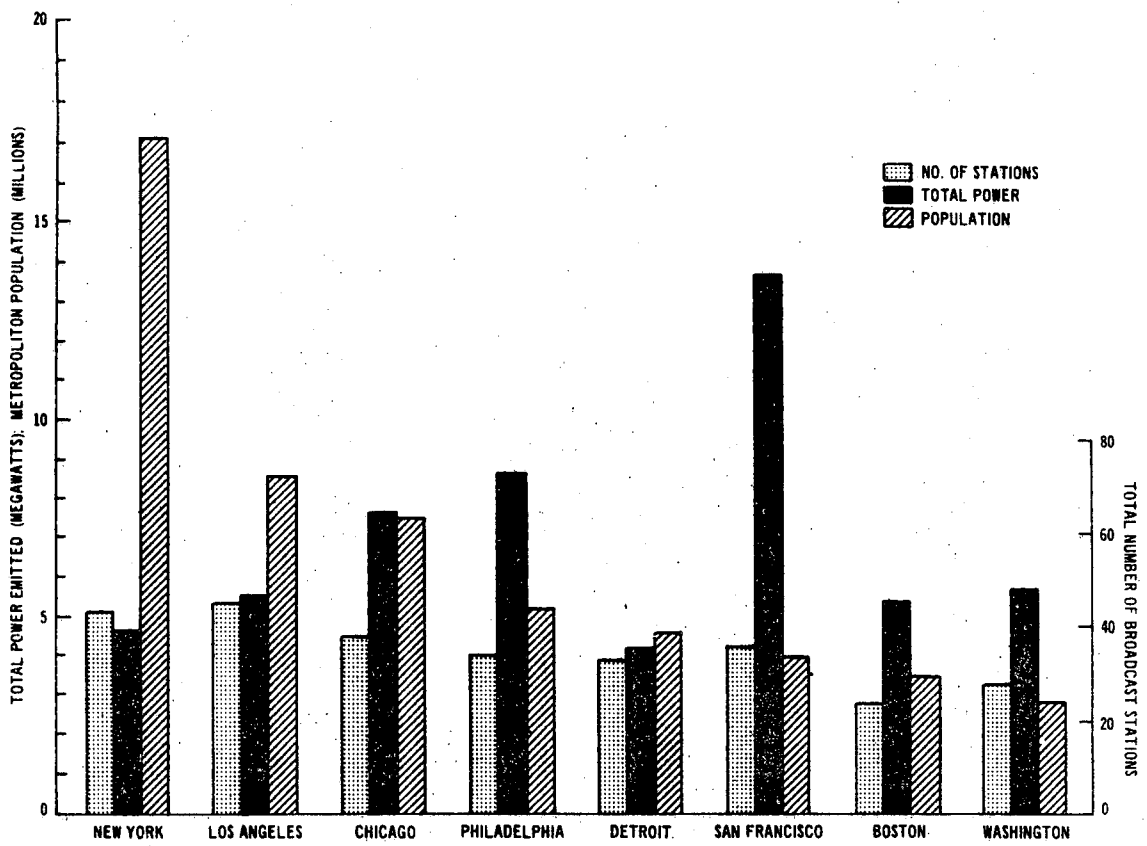


Figure 7. Number of broadcast stations and their emitted power in eight highly populated U.S. cities.

Increasing numbers of people are being exposed to increasing numbers of broadcast radiation sources. We have defined no hazards from these radiations at ambient power levels. If, however, a genetic or somatic effect is associated with the exposure to this kind of radiation at these power levels, it may show in health statistics taken from areas having the greatest total power levels and the largest populations--that is, the cities. Furthermore, if such a hazard were established, the health problem might be a large one because of the large number of people involved.

Radio and TV stations are permitted to broadcast with powers ranging from 0.001 to 5,000 kilowatts. Microwave stations operate at considerably less power from 0.0001 to 0.0450 kW, and radar stations broadcast at powers of 0.004 to 10,000 kW[2]. The latter two sources are highly directional, however, and do not expose as large a population as do the radio and TV waves. The total number of transmitters in an area, or the total power output of a single source may therefore not be as meaningful as considering the total power directed at a particular population.

One can make assumptions and calculate the power outputs from broadcast sources. These calculated values have little meaning, however, until they are related to actual power levels in the field and to some real biological effect. Field measurements should first be made in areas where the greatest powers are likely to occur. The measurements must include the whole broadcast region rather than selected frequencies, for only then can the field strength measurements show the total power in a location.

There are three major problems associated with field measurements. First, if one measures the field strength of the entire broadcast spectrum, the instrumentation must be capable of covering nearly ten orders of magnitude, essentially from about 10 hertz to 100 gigahertz. Secondly, the measurements must give absolute, not relative power density values. Finally, for the measurements to be meaningful, techniques for summing or integrating the power levels of all the frequencies in a particular location must be developed.

By using these measurements in theoretical calculations, models can be formulated to predict total power levels. Simultaneously with field measurements, an active bioeffects program must be carried out to pinpoint effects produced by controlled exposures approaching those encountered in the field.

From field measurements, theoretical calculations, and the results of biological studies, the existence or absence of the hazard may be established. The same information can be used in developing recommendations for exposure standards.

In the meantime the possibility of more people being exposed to more radiofrequency radiation increases. Populations move closer to transmitting stations, new stations are established, and new uses for the technology are developed. Recently, for example, a microwave system for transmitting converted solar energy in space to earth for conversion to electrical energy has been suggested as a substitute for electrical energy produced by nuclear reactors[8].

The proliferation of broadcast sources of radiation which are directed at people, plus the increasing use of nonionizing radiation sources, intensify the potential health problem--I stress the word "potential"--for an extremely large proportion of the population. That a hazard exists, at current environmental levels, has not been established. We must, however, measure and evaluate this radiation source before possible effects become apparent.

So large a population has never been exposed so nonselectively to any radiation source. Thank you.

References

1. Federal Communications Commission. Broadcast Services. Information Bulletin 2-B. Federal Communications Commission, Washington, D. C., 20554. October 1970.

2. Electromagnetic Compatibility Analysis Center, DOD, and Division of Electronic Products, DHEW. A Partial Inventory of Microwave Towers, Broadcasting Transmitters, and Fixed Radar by States and Regions (BRH/DBE 70-15). U.S. Department of Health, Education, and Welfare, Public Health Service, Bureau of Radiological Health, Rockville, Maryland 20852. June 1970.

3. Cleary, Stephen F. (ed.). Biological Effects and Health Implications of Microwave Radiation, Symposium Proceedings (BRH/DBE 70-2). U.S. Department of Health, Education, and Welfare, Public Health Service, Bureau of Radiological Health, Rockville, Maryland 20852. June 1970.

4. Broadcasting 1971 Yearbook. Broadcasting Publications, Inc., 1735 De Sales Street, N.W., Washington, D. C. 20036. 1971.

5. Bureau of the Census. 1970 Census of Population, United States, Advance Report, Final Population Counts, PC(VI)-1. U.S. Department of Commerce, Bureau of the Census, Washington, D. C. 20233. February 1971.

6. Television Fact Book No. 40, 1970-1971. Television Digest, Inc., 2025 Eye Street, N.W., Washington, D. C. 20006.

7. Jones, Vane A. North American Radio-TV Station Guide, 5th ed. Howard W. Sams and Co., Inc., and the Bobbo-Merrill Co., Inc., Indianapolis. 1968.

8. Glaser, P. E., Journal of Microwave Power, 5: 211 (1970).

PROFESSOR HILLBERRY: How extensive has the program on biological effects been? Starting back with the work at GE, way back, I know a considerable amount was done; and about 1939 we carried out some experiments at NYU hatching eggs in electromagnetic fields, about 5 to 15 meter wavelengths. The effects we got were utterly spectacular.

If you took the eggs and exposed them for the first five days and then sacrificed them at 10 days or something of this kind, you found that you turned up with creatures in which the nervous system was practically abolished, the embryos were essentially pinheads.

In a few cases we hatched some that had only been exposed for two days, and they looked like normal chicks, but they couldn't stand up. They just would wobble around the floor or roll over and over.

So on the basis that cyclamates are bad for people, because they can produce observable deleterious effects in experimental animals it would seem that electromagnetic exposure should be prohibited because it can produce effects in embryonic chicks.

I was just wondering--I had lost contact with the thing--how much work had actually been done in following through on the biological effects of electromagnetic radiation.

MR. JANES: I am not going to be able to answer that question in a short time. Let me say there has been a considerable amount of biological effects work done. One of the problems that we have is this large range of frequency. The most extensive work has been done in the microwave field, say above one megahertz.

I think that educated opinion at the present time, based on information which is currently available or any other reasonable words you would like me to use, would indicate the hazard that is currently found is associated with the creation of heat in the irradiated subject. This is why one sees effects in proportion to power density.

However, there have been some effects, and one must distinguish between effects and hazards, reported at low power levels, again in the high frequency range. I am talking now about a frequency range essentially out of the broadcast band.

There has been some work done at the lower frequencies. I think at current power levels there is a great deal of trouble in establishing what energy input must be or what the effects are. I think the important thing to note is that the number of sources is increasing, power levels in the environment go up, and this is an appropriate time to take a look at what the effects of this are and will be.

I hope that is responsive in the short time I have.

MR. JOHN W. SCOTTON: What kind of psychological effects have been reported?

MR. JANES: Changes in brain wave patterns. There have been some changes in behavior. I am out of my field now, so I can't describe with care the psychological testing techniques. But in some systems, changes in behavior for rodents which have been trained to do specific tasks have been noted under low power densities.

The Russian literature reports lots of things like people reporting irritability, headaches--I guess that is not psychological. That's physiological. These sorts of things.

MR. GARY SIRMONS: Concerning the FCC, do you know of any regulation or guideline that is issued to limit the number of stations that can operate in a given area? Do they have any guidelines as to the total power densities that are allowed in a given area?

MR. JANES: I don't know the answer to the question. Perhaps there is somebody else in the audience who is more familiar with FCC procedures than I am. I know that there is some compatibility in terms of frequency considerations that the FCC uses, but I don't know what criteria they use to look at the number of sources that a certain area can support?

MR. DON SNOW: Is EPA now integrating the total power in different areas across the country within the frequency range that you have indicated?

MR. JANES: We are exploring ways to do that. There are certain amounts of information available, but the techniques for integration are not clear at the present time. They are going to have to be developed. What this involves very briefly is that frequencies on

which the stations operate are not lines; they are areas. They have a band width.

If you sweep through the frequency range, then you have to use some technique for adding things up off-frequency as well as on-frequency. This presents some technical problems.

We have identified where sources are and we have gotten information about power densities, but we have not gotten into the computer programs that are required to sum over the frequency range. This problem is very interesting. I think we would like to weight power density with the population. I think that is an interesting number.

DR. ROY PARKER: The next two presentations, "Use of Health Statistics and Estimated Environmental Radiation Risk," and "Radiation Dose Effect Assessment," will be given by Edythalena Tompkins, Environmental Protection Agency.

Mrs. Tompkins, either give it as one paper or break it in two, as you may wish.

Mills et al., Nonionizing Radiation in the Environment, 3rd Annual National Conference on Radiation Control, (1971). Figure 4A

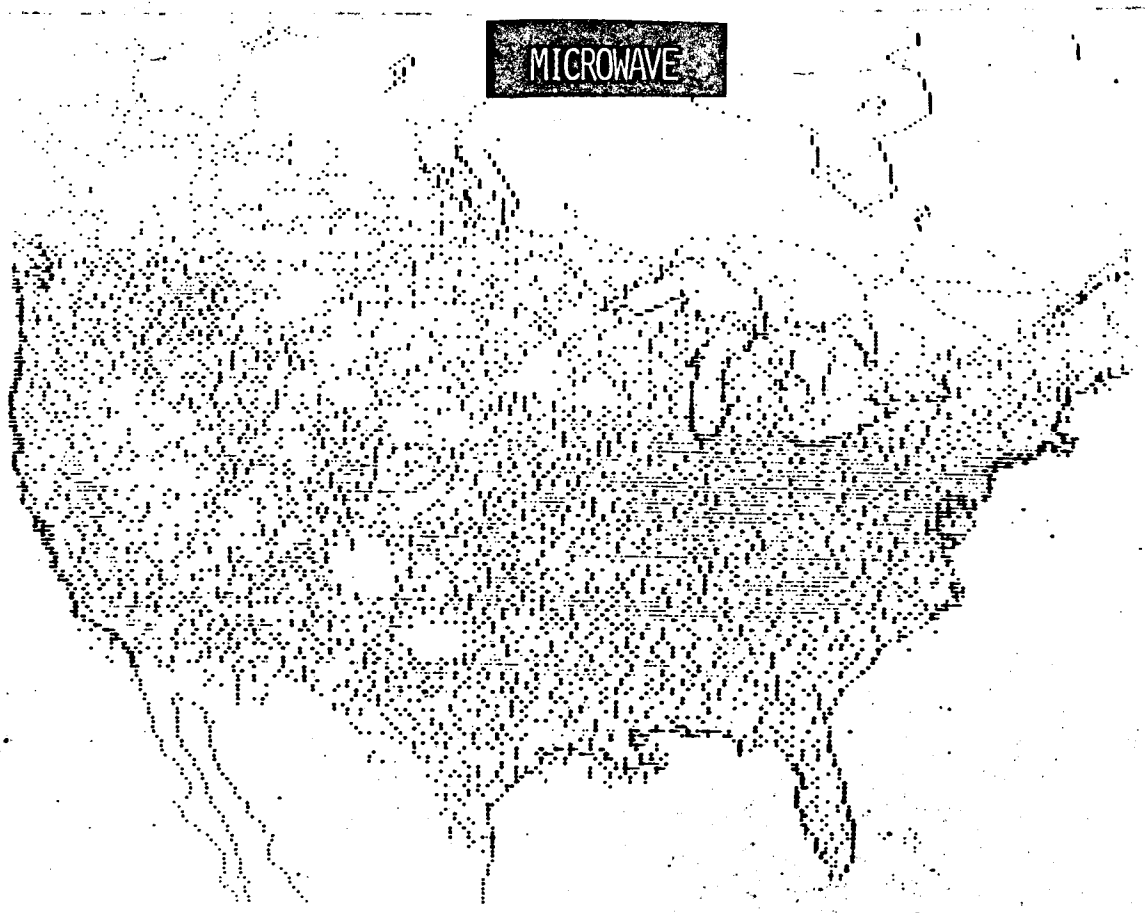


Figure 4A. Distribution of microwave stations in the U.S. This information was supplied by the Electromagnetic Compatibility Analysis Center in May 1971.

Mills et al., Nonionizing Radiation in the Environment, 3rd Annual National Conference on Radiation Control, (1971). Figure 4B

Figure 4B. Distribution of radar stations in the U.S. This information was supplied by the Electromagnetic Compatibility Analysis Center in May 1971

Mills et al., Nonionizing Radiation in the Environment, 3rd Annual National Conference on Radiation Control, (1971). Figure 5A

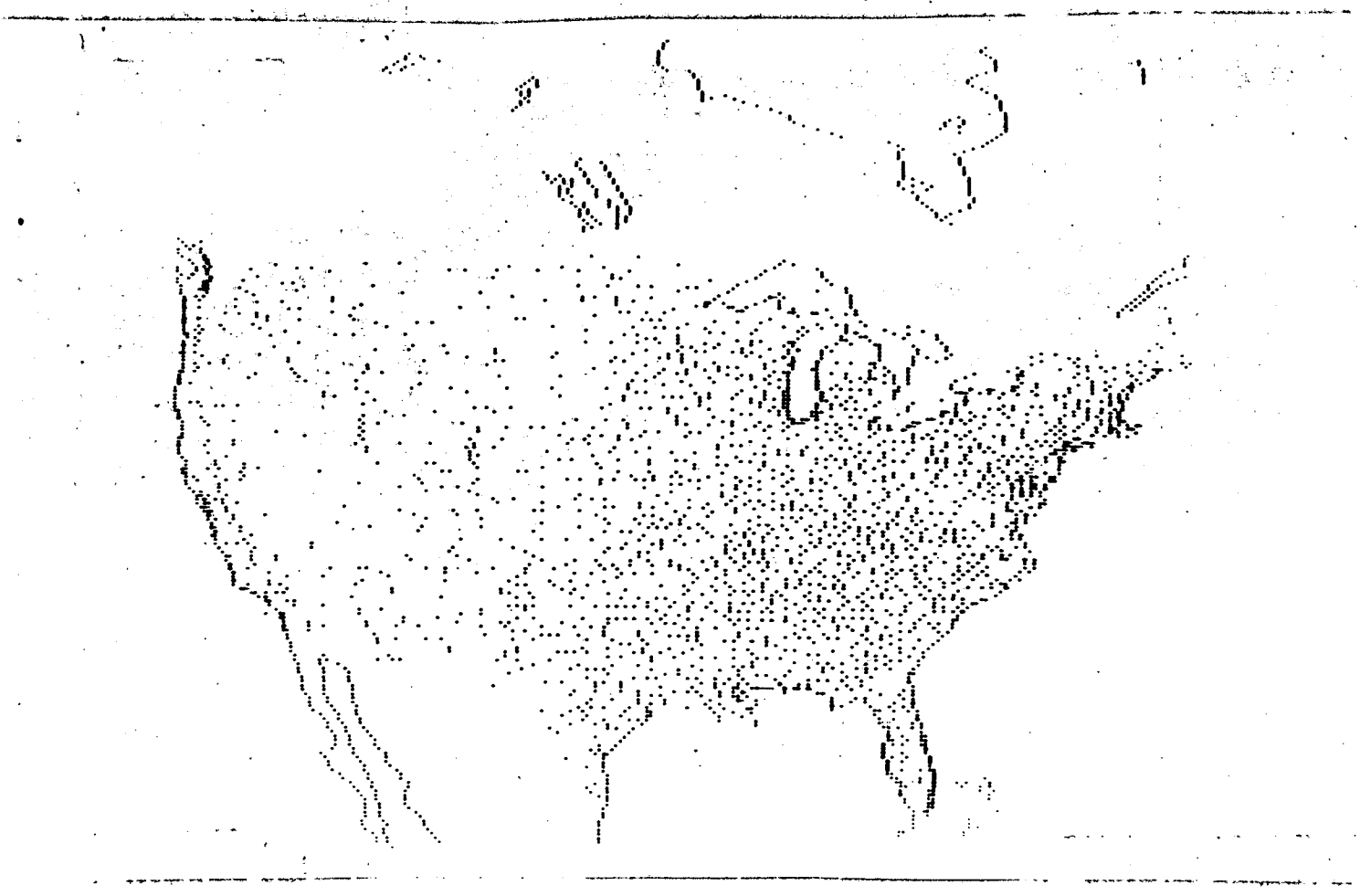


Figure 5A. Distribution of AM broadcast stations in the United States. This information was supplied by the Electromagnetic Compatibility Analysis Center in May 1971.

Mills et al., Nonionizing Radiation in the Environment, 3rd Annual National Conference on Radiation Control, (1971). Figure 5B

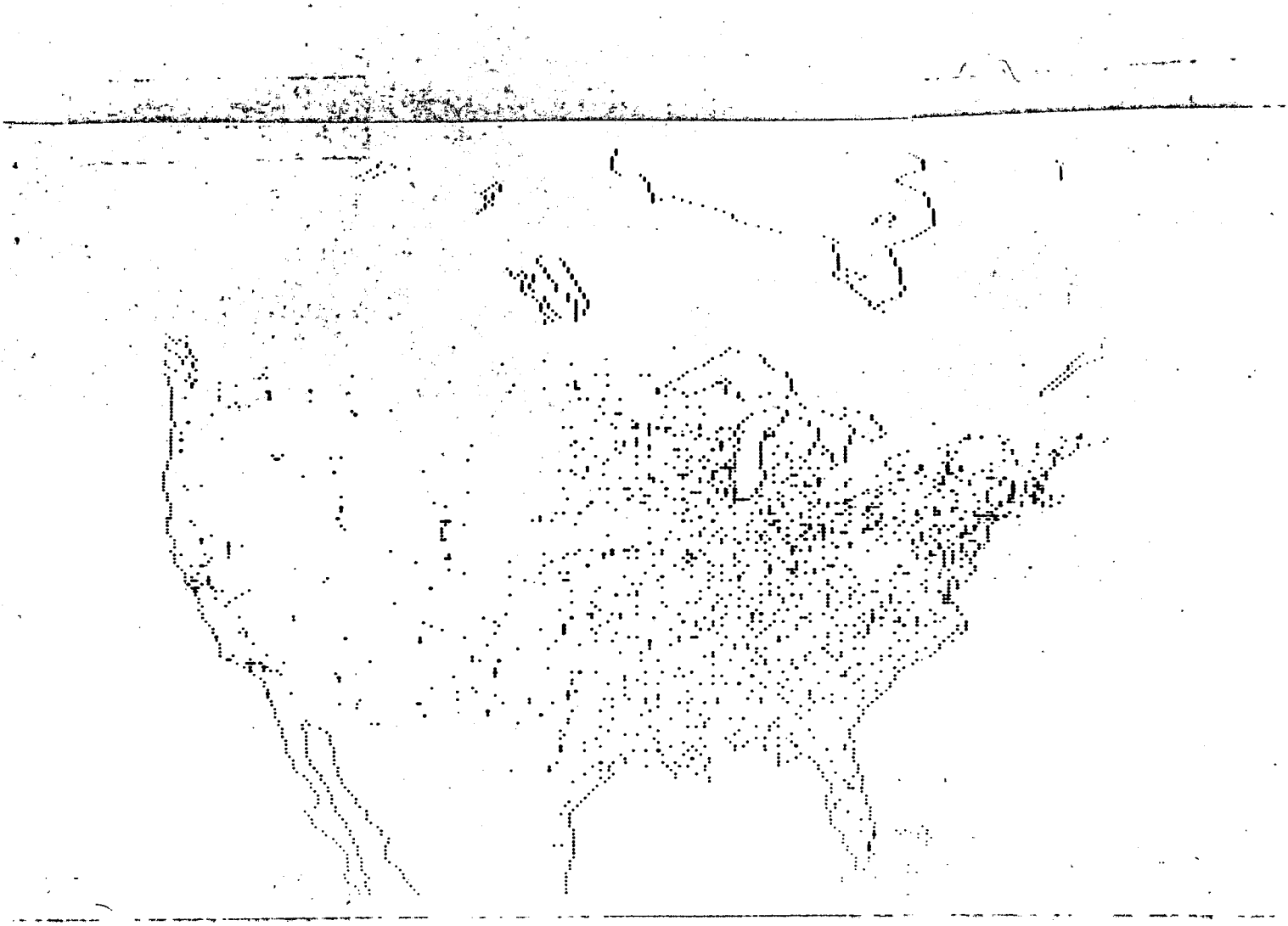


Figure 5B. Distribution of FM broadcast stations in the United States. This information was supplied by the Electromagnetic Compatibility Analysis Center in May 1971.

Mills et al., Nonionizing Radiation in the Environment, 3rd Annual National Conference on Radiation Control, (1971). Figure 5C.

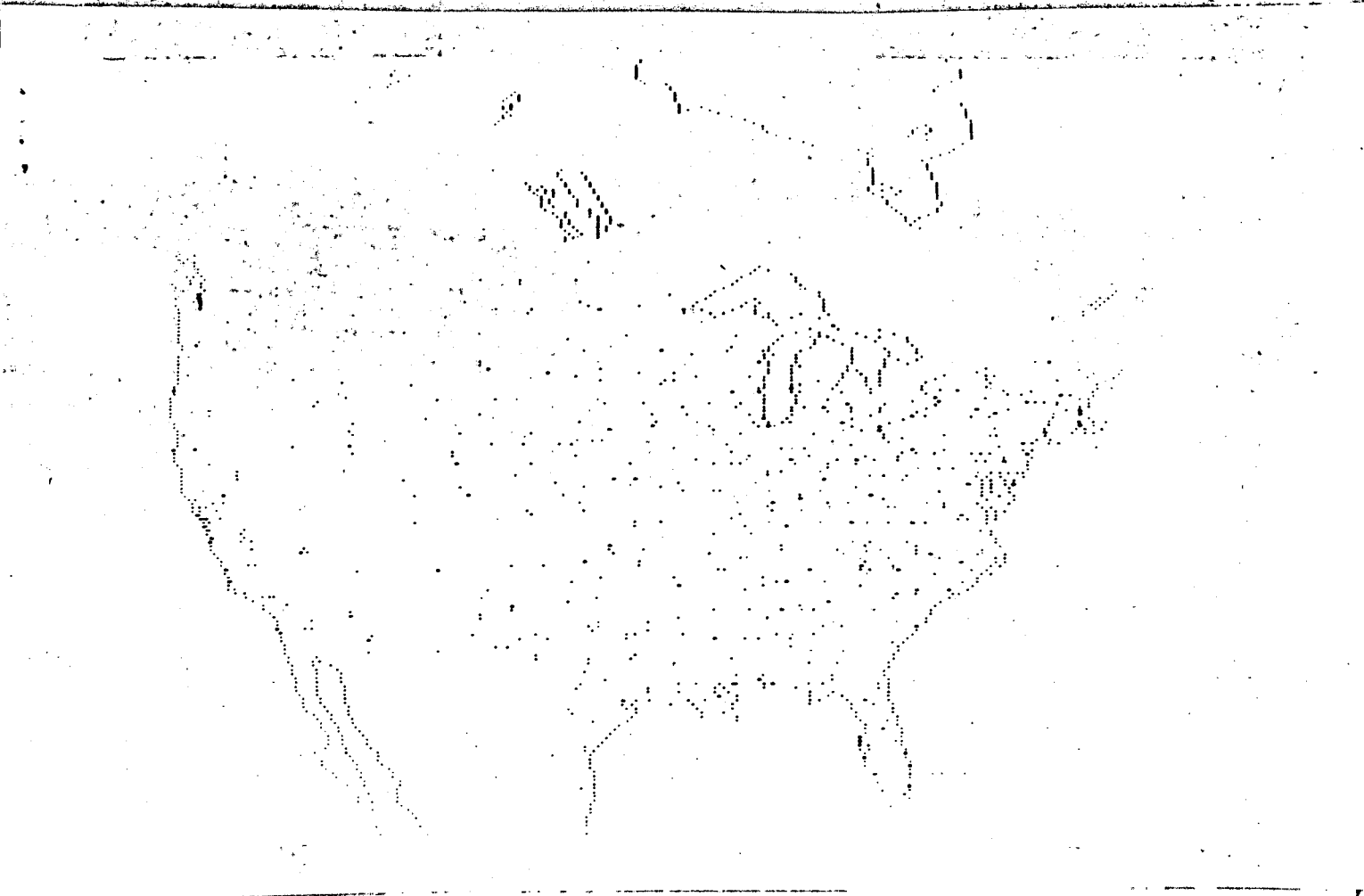


Figure 5C. Distribution of TV broadcast stations in the United States. This information was supplied by the Electromagnatic Compatibility Analysis Center in May 1971.