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RADIO FREQUENCY INTERFERENCE DOCUMENTS

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HEARING

BEFORE THE

SUBCOMMITTEE ON COMMUNICATIONS

OF THE

COMMITTEE ON COMMERCE,

SCIENCE, AND TRANSPORTATION

UNITED STATES SENATE

NINETY-FIFTH CONGRESS

SECOND SESSION

ON

S. 864

TO AMEND SECTION 302 OF THE COMMUNICATIONS ACT OF
1934 TO AUTHORIZE THE FEDERAL COMMUNICATIONS COM-
MISSION TO PRESCRIBE REGULATIONS WITH RESPECT TO
CERTAIN ELECTRONIC EQUIPMENT THAT IS SUSCEPTIBLE
TO RADIO FREQUENCY ENERGY INTERFERENCE

JUNE 14, 1978

Serial No. 95-117

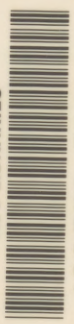
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RADIO FREQUENCY INTERFERENCE

WEDNESDAY, JUNE 14, 1978

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON COMMUNICATIONS,
Washington, D.C.

The subcommittee met at 10 a.m. in room 224 of the Russell Senate Office Building, Hon. Barry M. Goldwater, presiding.

OPENING STATEMENT BY SENATOR GOLDWATER

Senator GOLDWATER. The meeting will come to order.

Senator Hollings has asked me to express his regret at not being able to attend this morning's hearing. A death in the family required him to return to South Carolina last evening. Nevertheless, Senator Hollings stated that he will follow closely the activities within both the Government and the private sector to reduce interference problems associated with consumer electronic equipment.

At the outset, let me make it clear that while I have introduced legislation that would require certain actions on the part of manufacturers to overcome what is known as television interference, TVI, I would much prefer to see the manufacturers do this on their own without the Federal Government offering any regulations at all.

But this hearing will at least be an introductory way of accomplishing something in this field so long overlooked.

I am not married to the wording of my bill and, as I said in my opening words, whether it states that the Federal Communication Commission—FCC—shall require manufacturers to use "protective components" to reduce interference, as it does now, or is changed to authorize standards which manufacturers must follow in reducing interference is beside the point. The end result is the same: The reduction of interference.

Now, unfortunately, we are dealing with a highly complex matter that is viewed by the average citizen as a relatively simple one. As long as we have radio frequency used to transmit voice or other types of signals, we are going to have spurious harmonics or subtransmissions from the assigned frequency. These harmonics have been a source of study for many, many years, but as yet nothing concrete has come up that would indicate that we are even on the track of eliminating them at their source without extra circuitry, which involves manufacturers or owners or both.

The major point is that many, many American citizens are annoyed by citizens band interference or even amateur frequency interference

with their TV, stereo, or both, and I might add, all other forms of TVI. I might recall, in my apartment in California which is right above the ocean I could tell every time a boat started up because of the ignition TVI on my screen.

An FCC staff study dated July 1977 of actual interference situations, reviewed and investigated in the field, concluded that at least 4 million persons and upwards of 10 million were troubled by CB or other spurious interference to their TV reception. The staff has projected that in fiscal year 1979 up to 21 million persons will be bothered by TV interference from these same sources.

Now an approach has been made in the elimination of linear amplifiers which operate in the 10-meter field, and while it has been concluded that about one-fourth of the interference problems may be solved by this, it will not be the total answer because there is nothing in the law that prohibits 10-meter, linear amplification where the 10-meter equipment was used before the ruling was made. On the other hand, if all TV sets used a high-pass filter, the FCC study indicates approximately 40 percent of CB and other interference would be solved and 30 percent more greatly improved.

Now, this study was for a period during 1976 when there were far fewer CB operators than now. For example, in April of 1978 alone there were 218,000 applications for CB licenses, and this doesn't count the unknown number of thousands who operate without licenses at all. With over 20 million present CB users and the growing addition of millions more, it is obvious the interference will increase.

In fact, the total mass of citizen complaints is so overwhelming that FCC field offices no longer take complaints over the phone. They use telephone recording systems that tell the caller he must put his complaint in writing and send it directly to the FCC. The truth is that the FCC is currently receiving complaints at the rate 100,000 annually, and I liken this number to the tip of an iceberg. They are only the written complaints filed with the Commission directly. There is no record of the hundreds of thousands of attempted phone calls. Moreover, in many States there are no FCC field offices to call. The Commission only has 24 offices.

Let me repeat in a little different language what I said at the outset. It is not my intent to allow the FCC under this legislation to write regulations so strict they could, for example, impede the manufacture of top-line, high fidelity components. So long as any manufacturer can solve the problem in his own way, my bill is not intended to allow the FCC to require him to use any particular filter or circuitry.

As a person who has been active in amateur radio since the age of 12, I have nearly all of that time, particularly since the introduction of vacuum tubes and then transistors and solid state circuitry, been aware of the existence of spurious transmissions on certain frequencies. I might relate an incident that I think many of you might be aware of, but it is a classic.

There was a time in the city of Detroit when garage doors were very mysteriously being opened without the car operator punching his little gizmo, and they found out that it was caused by harmonics from a frequency, the guard frequency used by the Air National Guard. And when this was discovered, correction were made, and the garage doors have stayed close since.

Unfortunately, this is true in all spectrums of our frequencies, but particularly true in the 10- and 11-meter bands which is where citizens band operates, and these harmonics or spurious transmissions are the ones that affect television and to some extent stereo.

I have run experiments at my own residence here in Washington and at my station in Arizona, where I find that in operating my amateur equipment outside the 10-meter band I have no trouble at all with television or with stereo, but once I get around those frequencies, trouble begins and I have had to solve them through changes in the circuitry, capacitors, et cetera.

I well remember the first day the new church opened just below my home out on the desert, and lo' and behold, their electronic organ was beautifully receiving signals being transmitted by my station to the troops in Southeast Asia. But the complaint took only about a half an hour to adjust, and nothing has happened since.

We are not talking about high-priced work in these instances nor are we talking about high prices to manufacturers; we are talking about prices from a dollar or two to maybe \$10, at the most. But these interferences can be handled. In fact, if done correctly, they can be eliminated, and I see no reason for the industry to wait until the wrath of television viewers is lowered on their heads because of signals over which the transmitter has no control in a complete way.

So I hope as a result of these hearings that nothing more will be needed to get the manufacturer of television, stereo, and other equipment that transmit radio frequency to begin to cooperate in order that we can have equipment that will cut down interference to a point that there can be no complaints.

I am very grateful to the chairman for holding this hearing, and I am grateful to the staff that has done yeoman work in research, and I am happy with the people who have come here today to testify on this most important subject.

Now, I don't want to prolong my remarks too long, but indicative of the amateur operator's deep desire to clear this matter up, there is hardly a magazine published in the amateur field that I read that doesn't contain suggestions of how to prevent TVI. In fact, I just got the June issue of Ham Radio, and in it is an article on techniques for preventing RF leakage from your transmitter, and I want that made a part of the record at this point.

[The article follows:]

[Ham Radio, June 1978]

TECHNIQUES FOR PREVENTING RF LEAKAGE FROM YOUR TRANSMITTER

(By John E. Becker, K9MM)

LOWERING UNWANTED RF LEAKAGE FROM YOUR TRANSMITTER REDUCES RADIO-FREQUENCY INTERFERENCE

We are all aware of the increasing incidence of RFI problems caused by solid-state home entertainment products which are not designed to function normally in the presence of a strong RF field. These kinds of problems can be cured only by adding filtering and/or shielding to the affected device.

At the same time it behooves us all not to forget to be sure that our own transmitters are clean. This means using a good lowpass filter and making sure that the only path out of the transmitter for rf energy is through that lowpass filter. If you have any RFI problems, this is the first thing that should be checked.

Run your transmitter into a shielded dummy load. If the RFI is still present, you have rf leakage which should be eliminated. If it is harmonic interference, no lowpass filter will do any good if the harmonics are leaking out ahead of it. If it is overload interference, it may be possible to eliminate it by curing the leakage, depending on the amount of leakage to begin with and the relative distances from the equipment and the antenna to the device suffering the interference.

Three areas need to be addressed to solve rf leakage problems: filtering of power, audio, and control leads; shielding effectiveness of coaxial cable; and leakage at joints in shielded enclosures. Techniques for filtering of power, audio, and control leads has been thoroughly discussed in many amateur publications so that topic will not be addressed here. Instead, I will concentrate on the other two areas.

There is considerable difference in the shielding efficiencies of different types of coaxial cable. The numbers to be quoted are from manufacturers' literature, and while different manufacturers do not necessarily agree on the shielding efficiency of a particular type of cable, there is no doubt about the significant difference in the shielding efficiency afforded by the different types of cable construction to be discussed, and the numbers should be considered with that in mind. The most commonly used type of coax, that having a single shield braid of stranded copper wire, has a shielding efficiency of -48 dB at 100 MHz for a 30 cm (1 foot) length of cable. That is, the total power radiated by that 30 cm of cable is 48 dB down from the signal level in the cable. This assumes 95 percent shield coverage. This shielding efficiency increases only slightly with decreasing frequency, to -52 dB at 10 MHz according to data published by the Times Wire and Cable Company.

The shielding efficiency is significantly reduced by lower shield coverage, and 85-90 percent is more typical. This means that if you have 30 cm of coax between your transmitter and lowpass filter, harmonics radiating from that piece of coax are 48 dB down from their level at the transmitter output. Under these conditions, a lowpass filter with 100 dB harmonic attenuation is no better than one with 48 dB attenuation as far as nearby interference problems are concerned. The filter will keep the harmonics from getting to the antenna to be radiated for long distances, but the TVI problem next door is just as likely to be due to the radiation from the cable.

While we're still on the subject of single shielded coax, be especially wary of bargain prices coax that is not made to military specifications. Some manufacturers have drastically reduced shield coverage in the last few years to keep costs down.

There are more sophisticated types of coaxial cable with much better shielding efficiencies. The most often encountered construction is double shielded coax. This type of cable uses two shield layers with no dielectric between them. Shielding efficiency is typically -87 dB at 100 MHz for a 30 cm (1 foot) length, and since this is a premium cable designed for excellent shielding you can be sure that the shield coverage is as great as possible.

A still better type of construction for shielding efficiency is triaxial cable. This cable has two shield layers with a dielectric layer between them. Shielding efficiency is further improved to -97 dB at 100 MHz for a 30 cm length.

The ultimate in shielding efficiency is the solid jacketed type of cable. Radiation from this type of cable is below measurable limits, and system shielding efficiency is limited only by leakage at a connector interface.

The use of one of these improved types of cable for all station interconnections up to the lowpass filter will ensure that you are getting all the harmonic protection the filter is capable of. Double-shielded substitutes for RG-8A/U or RG-213/U are RG-9B/U or RG-214/U. The double-shield substitute for RG-58C/U is RG-55A/U or RG-223/U. A triaxial substitute for RG-8A/U or RG-213/U is Times TRF-8. A triaxial substitute for RG-58C/U is Times TRF-58 or Essex 21-204.

Whatever kind of cable is used, be sure the connectors are properly installed. An improperly attached shield will seriously degrade shielding effectiveness. With double-shielded and triaxial cables, both shields should be attached to the connector shell at both ends of each cable run. Assembly instructions for UHF, N, and BNC connectors can be found in both the ARRL *Handbook* and *Antenna Book*.

For sealing joints of shielded enclosures, the 3M company has two products that are hard to beat for effectiveness and ease of application. They are copper-

foil tapes with conductive adhesives, especially designed for RFI shielding. Type X-1181 is a smooth tape, and type X-1245 is embossed with a grid pattern for more reliable electrical contact with the surface on which it is applied. Both are available in widths from 6 to 25 mm ($\frac{1}{4}$ to 1 inch). Shielding efficiency of up to -65 dB is claimed by 3M, depending on the type of metal the tape is applied to. If desired, it is possible to solder to the tape without damaging it.

I have applied this tape to the edges of all shield enclosures in my equipment, to the seams of lowpass filter boxes and over the edges of coax connectors. The same piece has been removed and re-applied on my linear amplifier cover shield several times with no apparent loss of adhesion. If the metal surface is clean to begin with, the adhesion is excellent. This type of tape may also be spirally wound over a length of conventional single shielded coax to obtain improved shielding efficiency. Each turn should overlap the previous turn by half the width of the tape, and the tape should extend over the shell of the connector at each end.

Senator GOLDWATER. I have a short letter I received this morning from Motorola which I will place in the record. I don't mean to single this one out; we received about 10 or 12 in answer to inquiries. But Motorola happens to manufacture in my hometown, and I work very closely with them on this subject.

[The letter follows:]

MOTOROLA INC.,
June 12, 1978.

HON. BARRY GOLDWATER,

U.S. Senate, Russell Senate Office Building, Washington, D.C.

DEAR SENATOR GOLDWATER: My apologies for the delay in responding to your request for our views on S. 864. As you will see below, opinion on the Bill within Motorola is sharply divided—even within our various Divisions.

Our Automotive Division perhaps best illustrates this dichotomy. As producers of CB equipment, they are in favor of potential regulation if receiving equipment that, because of its design, is the real cause of "interference." However, this same Division manufactures AM and FM radios as well as providing components used in automobile ignition systems. In these areas, this Division views with alarm the prospect that the FCC can impose standards on these products.

Our Semiconductor Group manufactures computers; thus, it does not favor FCC regulation of these products. The Communications Group of Motorola would certainly agree that the quality of today's TV receiver could be greatly improved at relatively little cost. In fact, it would argue that the FCC should force TV manufacturers to produce sets of sufficient state-of-the-art technology to enable many of the archaic "taboos" to be reduced or eliminated, thereby permitting spectrum that is now vacant to be utilized.

In this regard, you may be aware that Texas Instruments under an FCC contract has developed a TV receiver that would provide substantially higher reception quality with more efficient spectrum utilization, and at minimum additional cost.

In our opinion, your statement on the floor of the Senate when you introduced S. 864 that in many cases the cause of the interference is not the fault of the transmitter but rather is in the receiver is basically correct. All too often complaints directed against an amateur or land mobile licensee are misguided; the fault turns out to be in the complainant's home receiver. In cases, such as CB, in which the transmitter has been found to be a major contributory factor causing interference, the FCC has proposed appropriately tighter technical standards to resolve that aspect of the problem effectively.

The question is how far should legislation reach in vesting authority in the FCC to develop and establish receiver standards. We are living in an age of electronics and their products from home computers to electric organs can be found everywhere. In fact, a recent speech by a member of the FCC's staff cautioned manufacturers of hearing aids that they could be faced with mandatory receiver standards. In light of the myriad devices in being and in the future which the FCC could be called upon to regulate, devices about which the Commission has no expertise; there is reason for concern that another highly expensive bureaucracy will arise.

Thus, it seems to me that a reasonable balance must be struck between the cost/benefit of regulation vs. protection to the public. To provide for standards

for TV receivers, the single biggest cause of complaints appears sound. The FCC not only has the expertise to formulate appropriate standards but also has the capability of properly enforcing adherence. To regulate a plethora of other "home entertainment" products in a similar fashion would require the employment by the FCC of vast numbers of new people knowledgeable in those areas. I query whether the candle is worth the flame.

I hope these views have been helpful; please contact me if you have further questions.

Sincerely,

TRAVIS MARSHALL,
Vice President, Motorola Inc.,
Director of Government Relations.

MOTOROLA, INC.,
June 14, 1978.

HON. BARRY GOLDWATER
U.S. Senate, Russell Senate Office Building, Washington, D.C.

DEAR SENATOR GOLDWATER: I would like to clarify and make a slight change in my letter of June 12. It is the principle of the Bill that I agree with because much of the interference is due to the television receiver rather than the Amateur, CB or Land Mobile Transmitter.

I do believe; however, that TV Receivers require improvements in order to obtain the necessary protection and this should be on a voluntary basis. Ideally, the market forces would cause manufacturers to build receivers that would be protected against most of the interference. If this cannot be done, certainly a voluntary industry standard should be set. Only if these methods fail, should we resort to further regulation and the resulting mandatory standard.

Sincerely,

TRAVIS MARSHALL,
Vice President, Motorola Inc.,
Director of Government Relations.

Senator GOLDWATER. I would close my remarks by reiterating what Mr. Marshall said, that there are other causes of interference than just the spurious transmissions or harmonics from the frequencies we've been talking about.

I recall, and I think many of you recall, the Pan American research done on spurious transmissions below Gila Bend, Ariz., the least frequency-occupied area in the United States. They tested everything from home washing machines on up to the most sophisticated transmitting equipment, and found that every single device they tested put out some kind of a harmonic. So while these harmonics have not caused problems with TV sets, there are other things that we will have to consider during either these hearings, or what I hope will happen—and I really mean this, because I don't want to see the FCC get into more regulation—I would like to see you manufacturers get your heads together and come up with some suggestions, either in improved circuitry or gadgets that can control this without having to burden you further with Government regulations. I don't believe in Government regulations, and I only used my bill as a vehicle to get you people together in a formal way.

[The bill follows:]

[95th Cong., 1st sess., S. 864]

A BILL To amend section 302 of the Communications Act of 1934 to authorize the Federal Communications Commission to prescribe regulations with respect to certain electronic equipment that is susceptible to radio frequency energy interference

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) section 302 of the Communications Act of 1934 (82 Stat. 290; 47 U.S.C. 302a) is amended as follows:

(1) Subsection (a) of such section is amended—

(A) by inserting "(1)" immediately after "governing" in the first sentence;

(B) by striking out the period at the end of the first sentence and inserting in lieu thereof ", and (2) the use of protective components in consumer electronic equipment from radio frequency energy."; and

(C) by striking out "shipment, or use of such devices" in the second sentence and inserting in lieu thereof "or shipment of such devices and consumer electronic equipment or the use of such devices."

(2) Subsection (b) of such section is amended by striking out "ship, or use devices" and inserting in lieu thereof "or ship devices and consumer electronic equipment or use devices".

(3) Subsection (c) of such section is amended—

(A) by inserting "or consumer electronic equipment" immediately after "devices" wherever such term appears in the first sentence;

(B) by inserting "and consumer electronic equipment" immediately after "Devices" in the second sentence; and

(C) by striking out "the common objective of reducing interference to radio reception," in the second sentence and inserting in lieu thereof "the objectives of reducing interference to radio reception and to consumer electronic equipment,"

(b) The heading for section 302 of such Act is amended to read as follows:

"INTERFERENCE WITH RADIO COMMUNICATIONS AND CONSUMER ELECTRONIC EQUIPMENT"

Senator GOLDWATER. Senator Schmitt?

Senator SCHMITT. All I can say, Mr. Chairman, is 10-4. I am happy my 20 is here today, and I will just be 10-10.

Senator GOLDWATER. 5-5.

All right, Mr. Ferris, you are first on the list.

Congressman Vanik will not be here until a little bit after 12, so we will hear from the present witness in any way you care to testify.

Senator SCHMITT. Mr. Chairman, could I just add one brief addition to the interference problem?

As some of us have seen in the newspapers recently, apparently the pacemaker is causing some concern, and I hope some of the witnesses will address themselves to that issue, also.

Thank you.

Senator GOLDWATER. Well, that has been known for some time. I have a good friend that lives near me in Arizona, and he knows every time my transmitter goes on. His ticker begins to go the wrong way. So he merely gets in his car and drives off.

Mr. Ferris?

STATEMENT OF HON. CHARLES D. FERRIS, CHAIRMAN, FEDERAL COMMUNICATIONS COMMISSION

Mr. FERRIS. Thank you; Mr. Chairman.

I might say at the outset that I share the reluctance that you have expressed, Mr. Chairman and Senator Schmitt, with respect to the FCC involving itself in this area and prescribing by regulation where otherwise the marketplace could provide the solution.

I would like, however, to thank you at the outset for the opportunity to review with you the provisions of S. 864.

Briefly stated, this bill would expand the Commission's authority to regulate electronic equipment by amending section 302 of the Communications Act of 1934.

At the present time this section of the act permits the Commission to adopt rules to govern the import, sale, offer of sale, shipment or use

of radio frequency devices. By definition, radio frequency devices are those equipments which by their design can emit radio frequency energy through radiation, conduction, or other means in sufficient degree to cause interference to other electronic equipment. They are frequently referred to as RF devices.

The number and type of individual RF devices now subject to Commission jurisdiction is very large. Included are, of course, the many kinds of radio transmitters used in the broadcasting, common carrier, marine, aviation, and landmobile services. The Commission also has the authority to regulate what are known as restricted radiation and incidental radiation devices.

Restricted and incidental radiation devices consist of a highly diverse array of technical equipment ranging from devices intended to generate RF energy such as garage door openers, industrial, scientific equipment, to devices where RF energy is unintentionally generated such as neon lights, electric motors, automatic ignition systems.

The Commission's jurisdiction under section 302 is principally concerned with devices which radiate RF energy. In its most significant aspect, S. 864 would extend section 302 to grant the Commission jurisdiction over passive nonradiating equipment. In introducing S. 864, Mr. Chairman, you stated that the bill is intended to reduce interference to consumer electronic equipment when operated in the vicinity of CB and amateur radio transmitters. This class of consumer electronic equipment includes a broad range of devices such as hi-fi equipment, phonographs, electric organs, intercoms, tape recorders, AM and FM radio receivers, and public address systems. Many of such devices have, of course, never been subject to Commission jurisdiction, including equipment certification and marketing regulations.

In anticipation of my testimony this morning, the Commission reviewed the proposed legislation at an open Commission meeting last Thursday, June 8. At this meeting the Commission was presented by its staff with divergent views on approaches to the interference problem addressed by S. 864 and the likely costs and effectiveness of proposed programs which might be implemented if S. 864 were adopted.

The Commission unanimously supports the bill's objective of minimizing interference to home electronic devices. We also recognize that S. 864 does not require the Commission to adopt specific regulations or rules applicable to a broad new class of electronic equipment. S. 864 merely confers the authority to do so in the future. Nevertheless, the Commission concluded that my testimony this morning should discuss the extent marketplace pressures might be effectively relied upon at this time to achieve the significant and worthy objective of S. 864.

The ultimate judgment with respect to S. 864 is, of course the Congress's. I hope that the Commission can assist this subcommittee in evaluating what steps can be taken to reduce significantly interference to home electronic equipment. In evaluating this bill we have considered the interference problem from an engineering and economic standpoint.

I'd like to outline for you some of the issues we reviewed. I'd also like to detail actions that the Commission believes can now be undertaken under its existing authority.

The Commission is aware that interference to home electronic equipment is a problem. With the proliferation of radiating devices in recent

years there has been undeniably a corresponding increase in the volume of interference to consumer equipment. Our field operations bureau reports that the number of complaints of interference to home entertainment equipment has increased over the years with 44,784 complaints to our field offices in 1975, 61,420 complaints in 1976, and 66,414 complaints in 1977. We are still not yet certain of the exact parameters of the problem, however.

This problem may in part reflect a temporary lag in the marketplace's response to a changing technological environment and recent rapid growth of CB services. Interference to audio and other equipment is obviously very annoying to consumers; and the impact of consumer complaints may not yet be fully reflected in manufacturers' design and production decisions. If the problem grows, I expect that manufacturers will become far more conscious of the interference susceptibility of their equipment. I believe that the Commission can, and should, encourage marketplace responses. This hearing should also have a very constructive impact in this regard; and the enactment of S. 864 might provide a stimulus to voluntary action even if the Commission did not adopt any formal regulatory program.

Many complaints about interference derive from use of older electronic equipment; and, of course, enactment of S. 864 can only have a prospective impact. In some respects, the problem might be a diminishing one. Effective January 1 of this year, the Commission adopted tighter standards for the manufacture of CB equipment. With the increased use of state-of-the-art equipment, there may be a corresponding reduction in the amount of interference to consumer electronic equipment. Moreover, we have also recently adopted stringent measures to restrict the interference problems created by linear amplifiers.

Because of our need to know more about the interference immunity and interference susceptibility of home electronic equipment, the Commission is moving quickly to institute an inquiry in this area; and I have directed the Office of Plans and Policy and other staff offices and bureaus to prepare a notice of inquiry for Commission discussion this summer. There are questions to be addressed both in the area of technology and in the area of economic impact, which are within the scope of this inquiry.

This inquiry will allow us to assess alternative regulatory approaches which might improve consumer equipment performance. We, first, need to know what is technically feasible before we can estimate costs. These costs to the public could result from higher manufacturing costs and higher government operating costs. Even if the cost impact on each device is only a few dollars, the cumulative impact on this Nation's electronics industry and its competitive position in domestic and foreign commerce could be substantial.

We recognize that the cost impact cannot be easily assessed in part because of a number of technical uncertainties. Admittedly, some interference problems might be solved simply by means of high pass or low pass filters; others may be more difficult to resolve because of significant uncertainties that remain in our technical understanding.

We ought to have more information, for example, on the environment in which electronic devices operate. If you think of interference susceptibility as something like the leakage of cold or hot air into a

building, then you can understand that we and the manufacturers need to know how cold or hot the outside environment gets, in terms of radio frequency energy. Only then can the manufacturers know how much insulation to build into their equipment. We really don't know either what a comfortable temperature is from an interference standpoint or how much we want to pay for it. At this time we do not even know how much information is already available, and how reliable it is.

Another important technical area deals with the standardization of measuring methods and measuring equipment. In our inquiry we will seek information on the current status of measurement standards, and what the FCC can do to help.

Another reason that we are concerned about measuring equipment is that while it is essential to any effective regulatory program adopted under S. 864, it could also be very expensive. Some of the measuring devices necessary in examining interference immunity, devices called anechoic chambers and TEM cells, are expensive custom-made items. The staff estimates that the costs of this equipment may range from \$10,000 to \$500,000 for some of these devices.

This testing equipment might, in the view of some, be a thin bottleneck of any regulatory program to reduce the interference susceptibility of nonradiating electronic equipment. It will not only be needed by the FCC to implement a type acceptance or equipment certification program, but it will also be required by manufacturers developing new products. Because of the likely expense and the limited availability of this equipment, large manufacturers could have a substantial competitive edge over small business just entering the market. And even if these small businessmen had the option not to meet FCC standards, they might well be at a substantial disadvantage in the consumer's eyes without FCC type acceptance.

The Commission believes it is essential to establish greater consumer awareness of the interference susceptibility of certain home electronic products. We will be trying to educate consumers about this aspect of equipment performance. As a first step we will urge consumer participation in our inquiry. In that proceeding we hope to examine the possibility of assisting consumers through a labeling program similar to that proposed by the Canadian Government. As we understand it, this program proposes several different quality levels for interference immunity and manufacturers voluntarily label products accordingly.

We also want to assess how electronic equipment manufacturers are now responding to the changing radio spectrum environment. I believe that the Commission, with the Congress in its oversight role, can focus public and press attention on a problem with potentially wide impact on consumers. Equipment manufacturers can, and should, be given an opportunity, a forum and incentives to explore voluntary industry-wide standards on interference susceptibility before a new regulatory program is authorized.

Finally, there are other ways that the Commission can now contribute to lessening the extent of interference with home electronic products. For example, we know that using long wires that connect the speakers to the stereo amplifier makes that system more susceptible to interference. A consumer education program could explain the use of shielded wires and good installation practices and might be quite beneficial in mitigating a significant part of the problem.

To summarize, Mr. Chairman, the decision about whether to confer additional jurisdiction rests with the Congress, but we hope to contribute constructively to the Congress determination with respect to S. 864. The Commission believes that the costs and benefits of alternative measures should fully be considered before any regulatory action is taken. If the Congress adopts S. 864, we would hope that the legislative history of the bill would make clear that the Congress intended to give the Commission discretion to decide what regulatory programs, if any, would be appropriate.

Whether or not the Congress decides to confer this authority at this time, the Commission will independently pursue under its existing authority the significant problem to which S. 864 is addressed.

Mr. Chairman, I thank you for the opportunity to present the Commission's views on S. 864. I would be pleased to provide further detailed views on S. 864 if the subcommittee wishes. And I want to assure you that the staff of the Commission will assist you fully as you address the issues presented by S. 864.

I will be happy to answer any questions you may have.

Senator GOLDWATER. Thank you very much for your testimony. I'm glad that you explained the Commission's position on my bill. And I want to repeat that I am in no big rush to pass this bill.

I hope we can accomplish what should be accomplished, through the cooperation of the manufacturers and better education of the public. We might also review the Pan American test made for the Signal Corps so we can make the public aware of the fact that every electrical device emits some frequency.

I understand from your testimony that the FCC has issued a notice of inquiry on the subject of RF interference. Would this notice of inquiry have been undertaken if hearings had not been scheduled on S. 864?

Mr. FERRIS. I'm sorry? Had this been scheduled prior?

Senator GOLDWATER. No. Would this notice of inquiry have been undertaken if hearings had not been scheduled on this bill?

Mr. FERRIS. I think there is a cause-and-effect relationship, Mr. Chairman.

Senator GOLDWATER. What has the Commission done about the interference problem?

Mr. FERRIS. Well, it has done some things in the past. The 40-channel decision with respect to CB's I think is going to have a significant impact. When the new standards with respect to emissions from CB's that are embodied in the new 40-channel sets are fully implemented—the entire inventory of CB's reflects those standards—there can be a significant reduction of interference.

If I recall correctly, the suppression level was raised from 40 db to 60 db, which is a significant improvement in these spurious emissions from the new equipment, but that doesn't take care of the inventory of the old 23-channel sets with the old, looser standards. So that is, I think, a significant impact, Mr. Chairman.

I think, with respect to general interference, the greatest amount of the interference of course is reflected in television. I think about 88 percent of the types of complaints that the FCC receives about home entertainment equipment, deal with television reception—the interference that they receive on that—but the followup studies that the field

bureau has done demonstrate that a lot of these people when you interview them, have complaints about other electronic equipment in the home. But it is just the television that gets them to the flash point where they want to call the FCC and complain, or to write to the FCC and complain.

Also I think the FCC did put out a well-received handbook dealing with the whole area of television interference and what can be done both at the home, and also as a guide to television repairmen with respect to putting in filters so that they can filter out a great many of these spurious and unwanted radio signals into the receiver.

So I think quite a bit has been done. But I think your bill has focused, and crystalized attention, with respect to other things that can be done; what the factual predicate should be with respect to any new authority if Congress does grant us the authority over these passive, nonradiating devices, how we would implement it if we had that authority, and how to do it in a way where we could keep the Government and the FCC out, where the marketplace itself can handle the problem.

We just don't have the data on that, Senator.

Senator GOLDWATER. Do you have members of your technical staff working on this problem all of the time?

Mr. FERRIS. They are; just on the response to the complaints that they get from the field, they are working on it. And I think there are other aspects. The Texas Instruments study, that the letter from Mr. Travis Marshall from Motorola alluded to, deals in part with this problem.

It is all interrelated—the problems of the efficient use of the frequency spectrum, and the type of spurious receptions and unwanted frequencies that give you an unintended response on whatever receiver you have, is all part and parcel of this problem that you raise here, Mr. Chairman.

And so I think I can say “Yes, that we are looking at this problem in relation to many other problems.”

Senator GOLDWATER. Do you meet with any group or groups of people that represent manufacturers so that you can mutually understand what each other is doing relative to this problem?

Mr. FERRIS. Yes; we have had, as a matter of fact, in relationship to the television receiver that you brought up, a full day of open hearings at the Commission with the manufacturers in dealing with proposed standards, and what their problems would be if the Commission took certain actions with respect to changing specifications of the manufacture of receivers.

We had a good give and take on that matter with respect to feasibility of certain options. And that was in an open session with all the Commissioners there.

But at the staff level, the Office of Chief Engineer is meeting continuously in response to inquiries and proposed rulemakings before the Commission. Comments are coming in from the manufacturers with respect to all of the impacts of any proposed rules dealing with any of the technical aspects of changing specifications from any of this equipment.

Senator GOLDWATER. You mentioned in your testimony some high-priced test equipment. I don't believe that the average manufacturer needs that. But I believe that some outfit like the FCC should have it;

because we are not talking about the whole spectrum of interference, but just what you see on your television screen, or might pick up on your hi-fi set.

While a requirement of low pass or high pass filters on receivers may not eliminate interference, if such a requirement were imposed as an intermediate measure, how far would it go toward remedying the present situation?

Mr. FERRIS. On television reception?

Senator GOLDWATER. Yes.

Mr. FERRIS. I could provide a detailed answer to that, Mr. Chairman, but I imagine it would be on the order of magnitude of probably 50 percent—well, about 40 percent.

Senator GOLDWATER. Is that all that you can get out of that?

Mr. FERRIS. Well, apparently. And I certainly could have the engineers give you a more detailed answer. With respect to the low pass filter, there is a segment between where you put the filter and where the signal goes into the set, which serves as an antenna as well. And so if you just add on a low pass filter at the entry end of the antenna, that takes care of anything coming down from the antenna. But if any wiring within the set itself could serve as an antenna, you won't filter out resulting interference. So I think you can add things with respect to the set, which become more costly, and ultimately you build a set to filter everything out, but I think there is a cost effective consideration, and choices have to be made.

This is the data with respect to the 40 percent.

Senator GOLDWATER. Well, could you submit that for the record?

Mr. FERRIS. We certainly would.¹

Senator GOLDWATER. I asked that question because ever since the introduction of television, it has almost been standard practice for the amateur operators who use RF equipment to go to the house or apartment of the person who is complaining and first find out where the signal is coming from. After you identify the signal, then at a very, very, low cost, sometimes under \$1, the cost depending on the set, you can eliminate that particular interference.

I don't look on this as the back-breaking, terrifically expensive thing that some manufacturers do.

Senator SCHMITT. Would the Chairman yield at that point?

Senator GOLDWATER. Yes.

Senator SCHMITT. Mr. Ferris, do you know of any manufacturers that are advertising interference-free equipment, such as television sets? Has it become a marketable item?

Mr. FERRIS. I am not familiar with any that are—and my staff shakes their head the same way.

Senator SCHMITT. Has anybody discussed whether or not that is a way to sell more television sets, by marketing interference-free sets? Have you heard this discussed?

Mr. FERRIS. Well, I think there is a public awareness. And as it is raised with respect to the fact that on some sets you do receive some interference, and some sets are better than others, I think those people who receive interference when they buy their next set, would be more conscious of it.

¹ See p. 24.

From the statistics and extrapolations that we've had, we might receive up to 10 million complaints if everyone called in. I mean, you are beginning to build up a segment of the marketplace where I think interference immunity could become marketable.

But I think, in the electronic industry, redesign of sets is very, very, tight, and when they put in a new component into a new set they get the cost down to a mil. I think it is so competitive that, to add \$1 in that type of an environment is significant.

So the industry does have a problem with respect to just adding \$1. It seems, at the retail end, that wouldn't be bad. And I think from that standpoint, if we can add the \$1 to every one that has a problem, and clip something on and that took care of the problem, the dollar charge would be very reasonable.

But to impose it from the front end—that every television set, or every piece of equipment must have this added \$1—I think you are beginning to deal with a different problem, and it might be somewhat overkill from the standpoint of the number of people that are actually receiving interference with respect to what their environment is.

We question whether that is the proper response, whether it is a tailored-enough response, whether it is surgical enough to respond to the real problem. We just don't know the dimensions of the problem and have the definition of it to the point where we can recommend a particular regulatory remedy at this time.

Senator SCHMITT. Mr. Chairman, thank you.

The record should show that, when I asked the question about marketability, there was a murmur of conversation within the room.

Senator GOLDWATER. Well, I will give them another murmur.

I recognize that, in any business—and I have been in business in my life—you give the businessman a chance to say “well, it is going to cost me \$1 to fix this,” and you're going to wind up paying \$5 more for it, probably.

I recall, not too many years ago, I purchased a television set—and I won't mention the manufacturer—but it was supposedly the best, for my wife, who is very hard of hearing—in fact, so hard of hearing that she can't hear television. So I made a little 4 watt amplifier for her hearing aid, and she was very happy with it.

But all of a sudden, the final-stage transistor blew out in the television set, so I called the dealer and asked him what happened. And he told me the transistor blew out. And I told him, “well, how could it blow out on such a high-priced set?” And he said, “well, it was a very cheap transistor.” And he said, “you won't believe it, but the total price of the transistor, and the loudspeaker, was under \$3.”

So all I did was go down and spend \$1 and buy a good transistor and put it in, and it works beautifully. I talked with the manufacturer, and I think since that time he has put in a \$1 transistor.

Somebody may be paying \$10 more for it—I haven't bought one since. To set the record straight, I have been handed a paper, FCC FOB PD & E 77-02, “Extent and Nature of Television Reception Difficulties Associated with CB Radio Transmissions.” On page 2, it states that if all CB stations employed a low-pass filter, and all TV receivers employed a high-pass filter, approximately 40 percent of all CB TV interference would be resolved, and an additional 30 percent improved.

Now do you presently have the authority to institute a labeling program?

Mr. FERRIS. I think we do on certain equipment. I would like to give a fresh cut to that, from the general counsel's office, Mr. Chairman. I think with respect to the passive, nonradiating equipment—the stereo, and things like that—I don't think that we could have a mandatory program.

I think we certainly could have a voluntary program similar to what the Canadian Government has, but I don't know what the basis would be of that type of a program because we don't know what the environment is out there. We don't know what we would be protecting against.

I don't know what we would say would be the best—because you want to know what the environment is; how significant an RF energy environment do you want to protect against? So that you could say that the stereo is protected against 9 volts RF energy, or 5 volts, or whatever the unit should be with respect to protection.

We don't know what the environment is; what we should protect against. I certainly think we could have a voluntary program that the manufacturers could subscribe to. The Canadians have proposed that. I don't think much equipment is manufactured in Canada, so it's very easy for the Canadians to have a voluntary program.

But with respect to having a mandatory program imposing standards, certainly with respect to the passive, nonradiating RF devices, I don't think so.

With respect to the others: Yes; I think you could.

Senator GOLDWATER. Would you ask your General Counsel to provide us an answer to that question?

Mr. FERRIS. I certainly will.²

Senator GOLDWATER. In view of the fact that the Commission, in several of its bulletins, has routinely blamed interference problems on inadequate design of home entertainment equipment, why hasn't the Commission in the past developed legislative initiatives in this area, or otherwise attempted to solve a problem attributable to receivers?

Mr. FERRIS. Well, I think the basic reason is: We don't have the authority to move, in the absence of your bill, Mr. Chairman.

But I think we have taken some steps with respect to, as I said, the transmitters, and with respect to educating, and disseminating home remedies with respect to specific TV interference problems. But I don't think we have the authority to prescribe the standards for stereos.

Senator GOLDWATER. I would ask that the FCC's Field Engineering Bulletins 24 and 25 be made a part of the record at this time.

[The following information was subsequently received for the record:]

[FE Bulletin No. 24, March 1972]

FEDERAL COMMUNICATIONS COMMISSION, FIELD ENGINEERING BUREAU,
WASHINGTON, D.C.

INTERCEPTION OF UNWANTED RADIO SIGNALS

Should your home electronic entertainment equipment, such as your television and other broadcast receivers or non-reception equipment, such as the record

² See p. 24.

player or stereo system intercept transmissions from a nearby radio station, you may be advised to have a filter installed or other modifications made to your equipment to resolve the problem. Your reaction may well be: "Why do I have to do something to my equipment? The equipment has performed well for years. I didn't begin to have this problem until a certain radio station came on the air. Why is it my problem?" Your reaction might also be: "My equipment is new and the salesman assured me the FCC would take care of the problem."

The answer is derived from the economics of volume sales of television receivers and other home equipment in a highly competitive market. Equipment such as TV receivers has two primary objectives: (1) to receive the desired television signal and convert it to a useful picture and sound, and (2) to reject unwanted signals. The ability of the receiver to accomplish the first objective can degrade its ability to accomplish the second unless certain design precautions are taken. The fact that your equipment intercepts undesired radio signals from a nearby station does not mean that station is operating on the wrong frequency or is deficient in other respects.

It is possible to manufacture "custom-built" TV receivers and other equipment to reject nearly all types of unwanted signals by installing in them complete shielding and special circuits. However, the cost of such special design would result in an increase in the price of television receivers. The competitive market place mitigates against "custom building" since the added features do not normally produce higher quality pictures and sound.

Perhaps less than one percent of the home equipment in use today will ever be located near any type of radio station such that the equipment receives radio signals which it is not designed, intended, or tuned to receive. If it does, it requires the installation of filters or shielding, or both. Most often, only one filter suffices and is obtainable from manufacturers, dealers, or servicemen.

Manufacturers believe it unfair to burden the mass consuming market with the additional cost of special circuits and designs inasmuch as the amount of equipment affected is relatively small. Therefore, in the less than one percent of instances where this interception is caused by insufficient rejection of strong unwanted signals by the television receiver or other equipment, most manufacturers, dealers, and servicemen have worked out procedures and processes for resolution of the problem.

The radio signal reception conditions at a particular location are not necessarily stable. Two situations may arise:

(1) The equipment user may live in an area where the average television receiver has no difficulty in rejecting unwanted signals. The situation in the area may be changed by the addition of a new station nearby, or by appreciable strengthening of existing signals by increase in power of a given station. Under these conditions, the situation has changed from that of a location in the ninety-nine percent category where no special treatment of the equipment is required to that of the less than one percent category where special treatment becomes necessary.

(2) An equipment user may reside in an area that is in the ninety-nine percent category having no strong unwanted signals and later move into an area where strong radio signals are prevalent. The situation has then changed from that of being located in the ninety-nine percent category where special treatment of the equipment is not necessary, to the less than one percent category where special treatment is required.

In most cases involving the interception of unwanted radio signals by home equipment, such as radio and television receivers, there are other factors present which contribute to the problem, e.g., lack of adequate maintenance of the receiver, antenna and transmission line. After a period of time, the overall performance of equipment generally deteriorates unless regularly serviced. Antenna connections become corroded and antenna elements bent or broken. The gradual deterioration of a reception system is not readily apparent to the untrained person. After a period of time, the quality of the desired signal is apt to become inferior and thereby make the system vulnerable to strong unwanted signals. It is important, therefore, that components of the signal receiving system be in good condition.

Information concerning the above is not necessarily widely distributed or fully recognized by all manufacturers, dealers, and servicemen. The statement of a salesman or dealer that he sells good quality equipment, or that there is nothing wrong with the unit, meaning the equipment adequately performs its intended function, is not enough and avoids the issue: Persons experiencing this

problem must fully recognize the situation involved. Regardless of the quality of the equipment, special treatment of it for rejection of strong signals is essential in some localities.

You are urged to bring this information to the attention of your serviceman, dealer, or manufacturer of your equipment.

[FE Bulletin No. 25, March 1972]

FEDERAL COMMUNICATIONS COMMISSION, FIELD ENGINEERING BUREAU,
WASHINGTON, D.C.

AUDIO DEVICES—INTERCEPTION OF RADIO SIGNALS

This bulletin is intended to assist you with the problem of interception of radio signals by a record player, Hi-Fi or stereo amplifier, tape recorder, public address system, telephone or the audio section of a television or radio receiver where the condition is observed on all channels or all across the dial. In the following discussion these units are referred to as "audio devices."

Audio devices are designed to amplify audio signals such as music or speech and are not intentionally designed or intended to function as receivers of radio signals. The Commission cannot give any protection to audio devices which respond to signals from a nearby radio transmitting station. The problem is not caused by the improper operation or by technical deficiencies of the radio transmitter. Strong radio signal energy gains entry into the audio circuitry, "overloads" the amplifier, is "rectified" and amplified, and appears at the loudspeaker as undesired sound. The only "cure" is by treatment of the audio device. You should therefore, contact a qualified technician, the dealer, or the manufacturer of your audio device (or telephone company for telephone problems) for assistance.

You may very reasonably ask, "Why do I have to do something to my audio device? It works fine except when the radio station is transmitting. Why is it my problem and not the responsibility of the operator of the radio station?" The answer lies in policies concerning the economics of the design and sale of these devices, in a highly competitive market. The device has two objectives: (1) to reproduce a desired audio signal and (2) to reject unwanted signals which may degrade the overall performance of the device, at a reasonable cost.

The state of the electronics art is such that it is possible manufacture "custom built" audio devices; that is, to install in them complete shielding and special circuits to reject nearly all types of undesired signals. The cost of special designs and circuitry would necessitate an increase in the price of the device.

Perhaps less than one percent of the total number of audio devices in use today will be located near the strong field of a radio transmitting facility whereby the device will respond to radio signals which it is not designed or intended to receive. If it does, it requires the addition of filtering or shielding, or both.

Manufacturers believe it is unfair and unnecessary to burden the mass consumer market with the additional costs of special circuits and designs inasmuch as the number of devices affected is relatively small. Many manufacturers, dealers, and servicemen have devised procedures and processes to improve the radio signal rejection capability of audio devices.

The conditions at a particular locations are not necessarily stable. Two situations may arise:

(1) The user may live in an area where the average audio device has no difficulty in rejecting unwanted signals present. The situation in the area may be changed by the installation of a new station nearby, or by the appreciable strengthening of existing signals by the increase in power of a given station. Under these conditions, the situation has changed from that of a location in the ninety-nine percent category where no special treatment of the unit is required to that of the less than one percent category where special treatment becomes necessary.

(2) The user may reside in an area that is in the ninety-nine percent category having no strong unwanted signals and later move into an area where strong radio signals are prevalent. The situation has then changed from that of being located in the ninety-nine percent category where special treatment of the unit is not necessary, to the less than one percent category where special treatment is needed.

Information concerning the foregoing is not necessarily widely distributed or fully recognized by all manufacturers, dealers, and servicemen. The statement of a salesman or dealer that he sells a good quality device, or that there is nothing wrong with the unit, is not enough and avoids the issue. Persons in possession of an audio device not capable of rejecting radio signals must fully recognize the situation involved. An audio device may perform the task for which it was designed with excellence and still require special treatment to improve its capability to reject strong radio signals in some localities.

You are urged to bring this information to the attention of your serviceman, dealer, or manufacturer of your equipment.

NOTE TO SERVICEMAN

The data received from the complainant indicates that the interference problem which is being experienced is coming from a nearby station below 54 Mc/s or an FM broadcast station in the 88 to 108 Mc band. If the station is below 54 Mc/s or you are unable to identify the station, try a good quality high pass filter across the antenna terminals of the television set. If the interference is from an FM broadcast station, try an FM band reject filter. High pass filters and FM band reject filters, with good rejection characteristics, are listed below.

Make	Model	Remarks
High pass filters:		
R. L. Drake.....	TV-300-HP.....	
Finco.....	3013.....	
FM band reject filters:		
JFD.....	TR-FM.....	General use, 10 db loss on channel 6.
Drake.....	300 FMT.....	Do.
Finco.....	3006.....	Do.
Drake.....	300 FMS.....	Especially useful for interference from stations in the low end of FM band where reception of channel 6 is desired.

In about 50 percent of the cases, a filter on the antenna terminals of the TV receiver will not fully remove the interference. There are a number of other possibilities: (1) the filter is not effective at the antenna terminals, place it at the tuner input terminals; (2) the filter may have insufficient rejection ability to reject the interfering signals sufficiently; two filters in series may be needed; (3) cross modulation may be occurring in an antenna signal booster amplifier generating a signal that can't be removed by the filter at the receiver; place the filter in front of the booster or remove the booster; (4) the antenna and/or lead in cable may have corroded joints causing cross modulation and thus generating signals that can't be removed by the filter; repair the antenna system or install new components as needed; (5) the receiver may be subject to audio rectification in the input of the first audio stage; a bypass condenser of 0.005 uf from the grid of the first audio stage to ground will usually solve this problem. (Treatment applies to tube type receivers only; consult the manufacturer concerning solid state receivers.)

Senator GOLDWATER. I'm putting these in the record, because they might not have been read by the manufacturers, and I want to be sure we're all playing in the same ball park.

You state that:

Equipment manufacturers can and should be given an opportunity, a forum, and incentives to explore voluntary industry-wide standards on interference susceptibility before a new regulatory program is authorized.

This implies that, until now, the industry has not had this opportunity. However, in 1974, Ray Spence, in a speech to the IEEE, said, in reference to the RFI problem:

One thing we can do is jawbone—and we have been doing some of that. This is what we are doing right now. We are trying to convince EIA, we are trying to convince these individual manufacturers, to the extent that we have any influence, we are trying to convince the importer that this is a problem and they had better get with it. The results, to date—and not too unsurprisingly—have been something less than totally gratifying.

Now there appears to be a conflict between these statements, and I would ask whether you or Mr. Spence would care to comment?

Mr. FERRIS. Well, I could have Mr. Spence write the committee and give what his 1978 version is of his 1974 statement, Mr. Chairman, if you would prefer that.³

Senator GOLDWATER. Well, I wish you would do that. In fact, I will ask the staff to get in touch with him, also.

You can make any statement you care to. Finding a way to stimulate voluntary action is really the essence of this problem. I always believe it's better to get people together to solve problems rather than have the Congress try to do so. With the exception of maybe four or five of us, nobody in the Congress knows what radio frequency means.

One more question: You referred to the difficulties and expense associated with measuring the susceptibility of electronic equipment to interference, yet you propose a labeling program.

Doesn't an effective labeling program assume that accurate measuring devices will be available? If not, can you explain what will be involved in your labeling program?

Mr. FERRIS. Well, I think the labeling program is one remedy. I don't think that we could adopt that immediately, either, Mr. Chairman, because I think your question implies exactly what the problem is: If we are going to have very precise standards that we would impose on either a voluntary and certainly on a mandatory program, you would have to have measuring devices to set the standards. And certainly manufacturers would have to have these measuring devices so that they would certainly be able to say that they met the standards.

And there is a bottleneck—a potential bottleneck—now with respect to that. So I want to make clear that, even if S. 864 were enacted by both Houses this afternoon and signed into law, the response by the FCC would not be immediate. We would have to go through the type of inquiry that we are starting up to find out what we can do, and what we can do that's reasonable for the manufacturers, and that is tailored to the real problem.

Because we have not defined what the problem is. And whatever remedy we choose—if you so impose this obligation upon us would have to have some precision to it.

And it is our understanding that the measuring equipment is just not readily available to provide that type of certainty, both for the manufacturers and for us.

So that would have to be developed in implementing any program or prescribing any timetable for any program. That would have to be a significant factor in any timetable.

Senator GOLDWATER. But there are many, many things that manufacturers can do now to cut down on the leakage of radio frequency. The books are full of these suggestions.

The major problem I see in attacking the linear amplifier is that you attack one part of the spectrum, while the entire rest of the spectrum remains perfectly open, with probably no way of eliminating RF under our present manufacturing standards.

Now in the June 12 edition of the *Washington Star*, there was a story about CB transmissions adversely affecting the operation of heart

³ See p. 23.

pacemakers. And you apparently plan to conduct an investigation of the problem.

Do you have the statutory authority to remedy the pacemaker problem? And would my bill give you the necessary authority?

[The article follows:]

[From the Washington Star, June 12, 1978]

FCC WILL PROBE EFFECTS OF CB'S ON PACEMAKERS

DETROIT.—The federal government is planning a study of the effects of citizens band radios on heart pacemakers because of complaints that CB broadcasts are making pacemaker users ill.

Three cases of illness brought on by CB broadcasts have been reported to the Detroit office of the Federal Communications Commission, prompting FCC staff members to ask this month for a major study of the problem.

Engineers from the Detroit FCC office documented one Ohio case in which the pacemaker user became dizzy, nearly passed out and had to take oxygen when a neighbor three blocks away broadcast on his CB.

The FCC said the user, a 57-year-old grandmother, was affected because the pacemaker implanted in her chest picked up electromagnetic signals from the CB.

A pacemaker stimulates the beating of the heart by sending rhythmic impulses of electricity. The device reacted to the CB signals by clicking on when not needed and caused the heart of Helen Hinderer of Marysville, Ohio, to beat faster than normal.

Hinderer said that whenever her neighbor talks over his CB, "It feels like something has shocked my heart. If he continues to talk any length of time, then the pain starts—up and down my neck, into my jaw and into my arms.

"Sometimes he would just knock me out, practically blow me off the bed. It kept getting worse and worse."

Hinderer said she had been hospitalized because of the problem. The situation continued, she said, even though her lawyer called the CBER and asked him to stop transmitting.

She said she connected the pacemaker problem to the CB one evening last summer when she became sick shortly after hearing a CB broadcast on her clock radio.

Hinderer filed a lawsuit last fall against the CBER, who denied his radio was the source of her discomfort. She later dropped the suit when the FCC took up the case.

FCC officials, who studied Hinderer's problem for eight months, said they received similar complaints from a second Marysville woman and from an unidentified pacemaker patient in Birmingham, Mich.

Garrett G. Lysiak, who headed the FCC investigation, said the interference of Hinderer's pacemaker occurred even though her neighbor's CB was operating legally without extra power boosters. The same was true in the Birmingham case, he said.

There are an estimated 250,000 to 300,000 Americans who use pacemakers. The number of people receiving them increases by about 10 percent annually. An estimated 13 million Americans own and use CB radios.

Mr. FERRIS. Your bill would give us the authority to get into that type of device, which is a passive device. I think, though, that the type of information that we have received on this particular case—I think that is the Detroit case—this is a rather unique case. And from the information that has been filtered back to us, I don't know if any standard would be prescribed as a solution, I think that is a rather unique case.

I think that particular pacemaker was certainly designed to take care of any sort of ambient RF energy that was in the air, and that certainly has the capacity to filter out any standard that we would set far about that—I think it is 30 times above any maximum standard that is considered.

So I think one has to look for the reaction both in the individual, and in that particular pacemaker, and maybe in its installation. It might be an unusual set of circumstances that caused that, but it is unique, and I don't think that that incident itself would require any sort of legislative or Commission response, nor is there any that could take care of it.

Senator GOLDWATER. But you are looking into it?

Mr. FERRIS. Yes; we are getting more information.

Senator GOLDWATER. Senator Schmitt?

Senator SCHMITT. Mr. Chairman, just to follow up on the pacemaker. Medical technology, in general, is regulated, is it not? Not by you, but is it HEW?

Mr. FERRIS. I imagine NIH does some of it. I imagine the Bureau of Standards does some of it.

Senator SCHMITT. Have you gotten those groups involved in this particular inquiry?

Mr. FERRIS. In this incident with respect to the pacemaker?

Senator SCHMITT. Yes.

Mr. FERRIS. No; we have not.

Senator SCHMITT. Do you intend to do so?

Mr. FERRIS. Well, it is being conducted out in the field now, out in Detroit by our field office. Also this morning, a letter went from our Bureau over to HEW on that particular subject.

Senator SCHMITT. Would you report back to the committee as soon as you at least determine how the various agencies concerned are going to work together on this, and what the scope of the inquiry is?

Mr. FERRIS. Absolutely. That certainly would be a factor in the inquiry that we will set in motion this summer, because that is one factor. It is certainly a more dramatic aspect of the passive devices, but it certainly would be included.

Senator SCHMITT. Of course, in the pacemaker area, as well as in many others, it might be useful—if you haven't already—to explore with NASA, also under the jurisdiction of this committee, some of the more advanced techniques that were used to prevent RF interference in spacecraft. That was always an area of major consideration, and major discussion in the configuration of the control boards, and any changes that were made.

I don't know whether you have done that yet or not, or whether they are part of your interagency group.

Mr. FERRIS. It certainly could be a part of the inquiry that we will get into in this whole area.

Senator SCHMITT. The implanted pacemaker is one of the more outstanding examples of the rapid application of technology gained from the space effort.

A final question is: Has your notice of inquiry been published—is that correct?—in the general area of RF interference?

Mr. FERRIS. No.

Senator SCHMITT. When do you expect that inquiry to be completed?

Mr. FERRIS. I directed it be prepared. We will take it up this summer, for publication.

Senator SCHMITT. Do you have a publication date?

Mr. FERRIS. Hopefully, we will go out with the inquiry this summer. It is in preparation now, Senator.

Senator SCHMITT. Assuming it is issued this summer—when will it be completed?

Mr. FERRIS. It is really awfully hard—it depends on the type of information you get. You are asking questions because you don't know the answers, and it depends upon the answers.

Senator SCHMITT. But you have a general feeling for the issue. What does your experience tell you about how fast you can move as an agency?

Mr. FERRIS. Well, my experience is 7 months with respect to the historical movement of the FCC, so it is awfully hard.

Senator SCHMITT. But you have been watching the FCC for a number of years.

Mr. FERRIS. I will give you a ball park estimate. An inquiry, going out and coming back, we might have our first cut at it within 9 months or a year. That is not a final rulemaking authority; that is just the first cut.

Senator SCHMITT. I understand that. That seems awfully long.

Mr. FERRIS. Well, the only thing is: The area is immense. For example, the point you've raised, Senator, with us this morning about going to NASA, and going to HEW, you know, with the whole range of these passive devices, everything has a very significant dimension to it. If you really want a fast development in an area like this, you either have to be precipitously arbitrary and just cut it off and say "No," we're not going to get involved with pacemakers; that is for somebody else; or we're going to be very cursory in our devices then we could be much quicker. But if you really want to explore the problem and find out what can be done, and what the implications of proposed actions are, it is much more difficult. All of the industries involved want to prepare comments, and then they'll want a look at everybody else's comments, and reply to them, and refute them, and it is an iterative process that goes on.

Senator SCHMITT. I recognize that, Mr. Ferris. But, you at least have a preliminary handle on the scope of the problem within a few months of the publication of the notice, so you could at least tell us whether or not you're going to need legislation or whether you're going to be able to work on the problem with existing authority?

Mr. FERRIS. Well, I would hope so, Senator. But I could not guarantee it. But we certainly, I think, by the beginning of the next Congress, we might be able to give you a better cut as to what the dimensions of the problem are, and maybe we might have some very good definitions by that time, depending upon the type of reaction we get to the inquiry.

Senator SCHMITT. Maybe it would assist you in accelerating the process if the committee made it clear that early in the next Congress we would expect to review the results as of that time. This would put everybody on notice that a public congressional review would be occurring, and maybe it would accelerate their rate of interaction with you.

Would you feel that that would be useful to you?

Mr. FERRIS. Well, it would certainly give me a sense of urgency that I could convey to the bureaus.

Senator SCHMITT. Do you have any feeling right now of whether or not legislation will be required, or do you believe you have authority,

or at least within the Government there may be sufficient authority to act, if any action is necessary?

Mr. FERRIS. Well, there is a school of thought that says, if you did pass S. 864 and it were signed into law, that that would be a very significant signal to the industries that Government was very serious about this problem.

Senator SCHMITT. But sometimes things like that, signals like that, run into interference.

Mr. FERRIS. Well, that's true and I recognize that. And personally, I prefer to know exactly what the expectations are from the Commission before we give them the charter to do it.

Senator SCHMITT. I agree with you and I hope that there is absolutely no regulation required and I'm sure Senator Goldwater feels the same way. There is a great deal of responsibility on the shoulders of industry, the transmitter manufacturers as well as the manufacturers of all receiver-type equipment to do everything they can to eliminate the need for any kind of governmental action. I hope that your inquiry process and the process that Senator Goldwater has initiated through the Commerce Committee, will encourage the private sector to take all of the necessary steps.

Generally, I hope the purpose of the Commerce Committee becomes more and more that of deregulation, rather than that of regulation.

Thank you, Mr. Chairman.

Senator GOLDWATER. You would not be upset at all if the manufacturers took this into their own hands and did what they should have done some time ago, would you?

Mr. FERRIS. I would be delighted if they would take the labor over and do it all voluntarily, Mr. Chairman.

Senator GOLDWATER. Well, thank you very much.

Mr. FERRIS. Thank you.

[The following information was referred to on p. 19.]

FEDERAL COMMUNICATIONS COMMISSION,
Washington, D.C., September 25, 1978.

HON. ERNEST F. HOLLINGS,
U.S. Senate,
Washington, D.C.

DEAR SENATOR HOLLINGS: This is in response to your letter of July 11, 1978 in which you requested answers to questions prepared by the minority staff on behalf of Senator Goldwater regarding my testimony on S. 864.

Enclosed are the answers prepared by Ray Spence, Chief Engineer Federal Communications Commission.

Sincerely yours,

CHARLES D. FERRIS, *Chairman.*

Enclosure.

ANSWERS OF RAY SPENCE, CHIEF ENGINEER, FCC

Question 1. Would you please provide the Committee with Mr. Spence's comments on this apparent conflict, (i.e., apparent conflict between testimony of Chairman Ferris and comments made by Mr. Spence in his 1974 speech to the IEEE)?

Answer. I do not believe there is any conflict between my views and the Chairman's. I have been informally (albeit as FCC Chief Engineer) jawboning the industry for some years. This has gone on under three FCC Chairmen and Chairman Ferris is/was aware of this. He is now saying we will escalate the level of effort to the full FCC by issuing a formal NOI. (Estimated release late September or early October.)

Question 2. What efforts have the FCC's Chief Engineer's Office made since 1974 to obtain voluntary reduction of the RFI problem?

Answer. Since 1974 I have on several occasions continued the jawboning and chiding approach. I do not specifically recall all the meetings and dates but feel sure I did use the subject material at the October 1975 Southwest EMC Engineering Conference in San Antonio. The general subject has also been covered in talks I have given at the PCS (Personal Communications Shows) in 1975 and 1976 in Las Vegas and the CES (Consumer Electronic Shows) in Chicago in 1976 and 1977. Various members of my staff have undoubtedly spoken on the subject at numerous meetings of professional groups. I have also discussed it on occasion with both the EIA and related individual company representatives.

Question 3. Have any manufacturers indicated that they will take action voluntarily?

Answer. Some have, most have been silent. Those that did were responding to the AARL RFI Committee letter inquiries. None have come to me to indicate any specific positive action.

Question 4. Which ones have cooperated?

Answer. See Q. 3 above as far as my direct knowledge/contact is concerned. I am aware that Radio Shack included a statement of relative RFI performance in their catalog listings for a short time (I believe late 1976).

Question 5. Is there any reason to believe that those manufacturers which have not cooperated in the past will cooperate now?

Answer. Largely unknown; if they begin to feel the "heat" of publicity or fear of formal regulation they probably will. The problem with the latter is we (FCC) do not have the authority and they know this. In the auto industry where we have authority (Part 15, incidental radiating devices) they have stayed one step ahead of the point at which we would propose rules. Jawboning has worked in this case because we have authority and could use it.

Question 6. What are the Chief Engineer's views on the likelihood of voluntary action?

Answer. I am not overly optimistic; lacking specific authority to act weakens our position. The picture is influenced by the high ratio of import products into a very cost-competitive market. Even EIA represents less than 50% of the U.S. manufacturers who, in turn, serve less than 15-20% of the market.

Question 7. Does he expect voluntary action to be sufficient?

Answer. See Q. 6. Given these limitations, I think it highly doubtful that purely voluntary action will succeed. The one exception could be a consumer revolt and consumer insistence on a better product. However, if we had the authority to promulgate rules if necessary, then I think a "voluntary" program would probably succeed as in the case of auto-ignition generated RFI reduction.

[The following information was referred to on pp. 13 and 15:]

FEDERAL COMMUNICATIONS COMMISSION,
Washington, D.C., October 23, 1978.

HON. BARRY GOLDWATER,
Dirksen Senate Office Building,
U.S. Senate, Washington D.C.

DEAR SENATOR GOLDWATER: This is in response to your request for additional information on several questions raised during the hearings on S. 864.

Enclosed are the answers prepared by Robert Bruce, General Counsel, Federal Communications Commission.

Sincerely,

CHARLES D. FERRIS, *Chairman.*

Enclosures.

Question 1. While a requirement of low-pass or high-pass filters on receivers may not eliminate interference if such a requirement were imposed as an intermediate measure, how far would it go toward remedying the present situation with respect to television reception?

Answer 1. Attached hereto are several reports prepared by Commission engineers which give a more detailed response to your question.⁴

⁴ Materials are available in the files of the Committee.

Question 2. What are the Commission's plans for mapping the environment?

Answer 2. The Commission staff is preparing a *Notice of Inquiry* on Radio frequency interference to electronic equipment due to be presented to the Commission in a few weeks which will explore this question. We will forward a copy of the *Notice* as soon as it is ready for release.

Question 3. What is the present Commission authority to institute a labeling program?

Answer 3. The Commission clearly has some authority to require the labeling of certain equipment. In considering the Commission's authority to require mandatory labeling of consumer electronic devices, we must look to the nature of the device and the information to be contained on the label. Specifically, we must consider whether the labeling requirement is reasonably connected with responsibilities assigned to the Commission by the Communications Act and authority vested in the Commission by that Act. If the Commission has authority to require that a device comply with technical standards, it clearly has authority to require that it be labeled to show compliance. If it will serve the purposes of the Communications Act, the Commission also has the authority to require labeling to show the extent to which the device exceeds the Commission's standard.

To be more specific, the Commission may under Section 302 of the Act make reasonable regulations regarding the interference potential of devices which in their operation emit radio frequency energy in sufficient degree to cause harmful interference to radio communications. It is also my view that, under Section 303(f), the Commission could require that receivers be labelled to show their susceptibility to radio frequency interference; such a requirement is reasonably related to the reduction or prevention of interference between stations. Under Section 303 generally, the Commission is responsible for efficient use of the non-Government radio spectrum in the United States; labeling which contributes to achievement of that purpose would be within the Commission's authority. Finally, labeling showing the receiving capability of television receivers would be reasonably related to the Commission's responsibilities under Sections 303(s) and 330 of the Act. In each instance, it is of course necessary to show a reasonable connection between the content of the label and implementation of a statutory provision.

The Commission would have no authority to institute any labeling program that is not reasonably connected with the Commission's statutory mandate. Additional statutory authorization would most likely be necessary if the Commission were to require mandatory labeling of consumer electronic devices which do not emit radiation and are not receivers.

Senator GOLDWATER. Our next witness will be Mr. John Lyons, Director of the National Engineering Laboratory, National Bureau of Standards—NBS. And he is accompanied by Mr. Charles Miller. And I notice that you have two statements. We will put one in the record.

STATEMENT OF DR. JOHN W. LYONS, DIRECTOR, NATIONAL ENGINEERING LABORATORY, NATIONAL BUREAU OF STANDARDS; ACCOMPANIED BY CHARLES MILLER, CHIEF, ELECTROMAGNETIC INTERFERENCE PROGRAM; AND SAMUEL EDWARD PROBST, DIRECTOR OF SPECTRUM PLANS AND POLICIES, NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

Dr. LYONS. With your permission I would like my full statement and an article to be made a part of the record. I will read a very short oral statement, and then take questions.

Thank you, Mr. Chairman. I am John W. Lyons, Director of the National Engineering Laboratory of the NBS. One of the larger units in the Engineering Laboratory is the Center for Electronics and Electrical Engineering. Our work on electromagnetic interference or EMI is carried out in that Center. I have with me the Chief of our EMI

program, Mr. Charles Miller; and seated behind me is the Chief of the Electromagnetic Fields Division, Dr. Hal Boyne. Dr. Boyne's responsibilities include EMI and a number of other programs. He can assist us should the discussion range beyond EMI.

In addition, I am accompanied here today by Mr. Samuel Edward Probst, Director of Spectrum Plans and Policies of the National Telecommunications and Information Administration. Mr. Probst can answer questions on that agency's activities.

The NBS has conducted studies in the field of radio since 1904 under various organizational names: The Radio Section, the Central Radio Propagation Laboratory, the Radio Standards Division—later the Radio Standards Laboratory—and currently the Electromagnetic Fields, Electromagnetic Technology, and Time and Frequency Divisions at Boulder, Colo. The Bureau has been studying the phenomena included under the rubric of electromagnetic interference sporadically for nearly two decades and in a formal program for 2 years. Our present effort is a sizable one for NBS, with \$1.2 million and 20 people assigned. A review of the marketplace shows the following:

First, sources of electromagnetic radiation are proliferating at an increasing rate.

Second, that products containing electronic control systems are also proliferating at an increasing rate.

Third, that ambient electromagnetic radiation can be picked up by electronic control systems and can interfere with their functions.

And finally, that people can absorb some of this radiation.

The NBS has been studying two parts of the EMI problem: First, how to measure ambient radiation; and second, how to measure the effect of such radiation on the operation of electronic circuits. We are not working on the biological effects of electromagnetic radiation, but we note that valid biological experiments cannot be performed without careful definition of the radiation levels employed. We do provide advice on this aspect of the experimentation to some of the laboratories doing such studies.

The status of our work is that, while progress has been made, there is much to be done. Our assessment of the state of the art may be summarized as follows:

First, we can measure ambient electromagnetic radiation adequately far from the source for approximately constant power levels, so-called far field measurements.

Senator GOLDWATER. What do you mean by "far"?

Mr. MILLER. The distance is a function of frequency and the antenna design. "Far" at one frequency can be several miles away; at another frequency it could be reasonably close.

Senator GOLDWATER. Thank you.

Dr. LYONS. Second, we are only beginning to understand how to measure ambient radiation close to the source and have special difficulty when there are several sources.

Third, we have developed a test device called the TEM cell which has been used successfully to determine the response of electronic circuits to specified levels of radiation. This cell is inexpensive and is now available commercially.

The Bureau plans to continue its measurement studies. It seems to us clear that there should be a common measurement methodology used

by the many Federal agencies and private sector groups concerned with resolving the EMI problem. We take the development of this measurement methodology as our responsibility. I shall be pleased to try to answer any questions you may wish to pose. Thank you, Mr. Chairman.

Senator GOLDWATER. Thank you very much. Your comprehensive explanation of the problem of RF interference is most helpful. However, it is not clear from your prepared statement whether you support the bill. Do you support it?

Dr. LYONS. I will turn that question over to Mr. Probst.

Mr. PROBST. Thank you.

Senator, NTIA heartily supports the intent of the bill, the reduction of television interference. We share the views you expressed in your introductory remarks and those expressed by Chairman Ferris of the FCC, that if these means can be obtained without regulation, that would be the most desirable course of action.

Senator GOLDWATER. During the course of your studies, have you come to the conclusion that a reduction of frequency interference can be accomplished on a voluntary basis by manufacturers?

Mr. PROBST. Again, that's a difficult question to answer, Senator. It varies from situation to situation.

Senator GOLDWATER. Let's confine it to television interference, and possibly include interference with stereo, although I am not completely convinced in my own experiments that the sources are the same.

Mr. PROBST. I share that view. I think the ability to which market forces can affect the solution depends in very large measure on consumer education. The average consumer at the present time does not think in terms of blaming his own equipment when he gets interference. He always thinks in terms of blaming that guy with the CB base station down the hall, or the amateur across the street. He says, "I paid a high price for this piece of equipment; it has to be good. The interference has to be his fault." It is a problem of consumer education.

When a consumer realizes that, at a slight increment in cost, he can buy a better piece of equipment that is less susceptible to interference, then perhaps market forces can be brought to bear.

Senator GOLDWATER. Or the manufacturers of the less expensive equipment could incorporate filters or circuitry that could help to eliminate it. But at the time of the sale it should be, in my opinion, a responsibility of the salesman to make sure that the buyer understands the importance of the proper antenna, the importance of shielding, and so forth and so on. Would you agree with that?

Mr. PROBST. I would agree that that is perhaps one of the best points at which to try to educate the consumer, through the salesman. The matter is extremely technical, and it's difficult for many of the consumers to even understand the salesman's explanation.

Senator GOLDWATER. Do you have any questions, Senator Schmitt?

Senator SCHMITT. Just one question.

Have you evaluated the impact of alternative means of regulation with regard to the import and competitiveness of foreign manufacturers of electronic equipment?

Mr. PROBST. We have done no specific study on that matter; no.

Senator SCHMITT. Would you care to comment one way or the other? Would you care to supply something for our record?

Mr. PROBST. I would prefer to respond for the record.

Senator SCHMITT. Would you do that?

Mr. PROBST. I certainly will.

[The following information was subsequently received for the record:]

If S. 864 should be enacted, the FCC would then have the authority to regulate imported equipment, and such regulation, if not clearly applied in an equitable manner to domestic manufacturers as well, would certainly be regarded as a non-tariff trade barrier. American manufacturers, on the other hand, should be allowed the freedom of their own decisions in seeking to make their equipment, designed for export, competitive in the world market. Again, it would appear that voluntary adoption of interference reduction techniques by the manufacturers, would be a preferable course of action as compared to further regulation.

Senator GOLDWATER. When will you complete the mapping of the electronic environment; and if you had additional resources, could it be accelerated?

Dr. LYONS. Mr. Chairman, the Bureau is not mapping the environment. We are developing the test methodology, and other agencies will presumably do the mapping. At the moment, the EPA is conducting field studies, attempting to get a handle on that question.

Senator GOLDWATER. The EPA?

Dr. LYONS. EPA is making some field measurements now.

Mr. MILLER. They're primarily doing it in connection with the biological effects of nonionizing radiation. There is no agency of the Federal Government assigned the responsibility, as of this time, to map the EMI environment throughout this country. Such mapping would provide information that would be useful in developing test criteria for interference-free design of electronics equipment.

Senator GOLDWATER. Are you making headway?

Mr. MILLER. Well, the EPA has done 12 cities.

Senator GOLDWATER. Is anybody doing the mapping?

Dr. LYONS. No, sir, not in any systematic way.

Senator GOLDWATER. Whom do you think would do it if the committee asked that it be done?

Mr. MILLER. Well, the agencies that have the capability are the EPA, NTIA, and the FCC. They have vans that have equipment that can map the EMI environment. If, however, electronic manufacturers go more to digital electronics, they're going to have to have much more information than can now be measured by the equipment on those vans. They are going to have to know various other pieces of information if they are truly to make an assessment of whether their electronics can function in those environments.

The FCC also has capability in this area.

Senator GOLDWATER. Could the Bureau supply, for the record, its views on mapping—whether and how much would it cost? The manufacturers will need a broad understanding of the sources of electronic interference, such as the linkage from transmissions.

Dr. LYONS. That is correct, Senator. We have talked to a number of groups in the private sector—for example, the Motor Vehicle Manufacturers Association—about this problem, and the first response we always get is: We don't know how to design, say, a microprocessor that is going onboard an automobile until somebody tells us the EMI environment through which that vehicle will be driven.

Senator GOLDWATER. Well, don't you think it's a good idea, then, that somebody be able to tell them?

Dr. LYONS. Yes, sir.

Senator GOLDWATER. The Government tells them how to do everything else. They might as well include this.

Well, I would appreciate it if you would supply that for the record, and we will ask the same of the FCC and the EPA.

Dr. LYON. We will be glad to.¹

Senator GOLDWATER. Thank you very much for your testimony, gentlemen. Keep up your good work.

[The statement and article referred to follows:]

STATEMENT OF JOHN W. LYONS, DIRECTOR, NATIONAL ENGINEERING LABORATORY,
NATIONAL BUREAU OF STANDARDS, DEPARTMENT OF COMMERCE

Mr. Chairman and members of the subcommittee, I am pleased to have this opportunity to represent the Department of Commerce in responding to your request for our assessment of the problems, effects, and possible measures for dealing with electromagnetic interference.

SCOPE AND MAGNITUDE OF EMI PROBLEM

We are witnessing a rapid proliferation of sources of electromagnetic radiation. Wider use is being made of Federally authorized frequency bands for industrial, safety, law enforcement, broadcasting, citizens band, and defense applications. Sources of electromagnetic radiation include the 9 million transmitters authorized by the Federal Communications Commission (FCC) as of 1977 including the 4,500 AM and 4,000 FM radio stations and 1,000 TV stations; point-to-point microwave communications relay towers, satellite ground stations, the 40,000 circuit miles of overhead extra-high voltage (345 to 765 kV) AC electrical transmission lines; and the 30 million citizen's band radios estimated to be now in use. Added to this list are those sources of electromagnetic energy used for consumer, industrial, scientific, and medical purposes. These include microwave ovens (an estimated 2 million in use), are welders, combustion engine ignitions, electric motors, high voltage switches, and intrusion protection systems.

On the other hand, we are also witnessing an applications explosion resulting from remarkable technological advances in semiconductor technology that have led to breakthroughs to lower prices, to increased effectiveness, and to new electronics applications.

Extensive use is being made of electronics for control of household appliances, traffic, business machines, industrial processing, medical diagnostics, patient care, etc. Designers and planners are looking to microprocessor-based technology for the competitive edge in domestic and international markets for products ranging from consumer products to massive industrial production line machine control, from processing plant needs to subway and rapid transit control, etc. Further applications exist in industrial intrusion devices, medical patient care, and covert communications. Automation of industrial processes is part of a demand for tighter process control to prevent waste, increase productivity, and lower energy requirements.

Consumer electronic products include watches, calculators, electronic games, intrusion alarms, home video players and recorders, besides the traditional home entertainment products of television, radio, and hi-fi systems. Further, electronic controls are invading the product lines of washers, driers, refrigerators, blenders, toasters, ranges, mixers, etc. By all indications, more electronics will enter the home in information systems, safety devices, as convenience features on appliances, and energy manager aids, to name a few. The consumer will see more use of electronics in his automobile for pollution control, fuel management, safety equipment, and convenience considerations. These electronic devices are susceptible to interference from stray electromagnetic radiation whose effects may range from a temporary disruption of function to subtle alteration of commands in a microprocessor, to product failure.

For example, the trucking industry has responded to Department of Transportation requirements for antiskid braking systems by installing electronic control

¹ See p. 36.

systems in trucks. In a study of seven such braking systems conducted by NBS, only one was found to be relatively free from electromagnetic interference effects in the range 10 MHz to 1 GHz (the range of most TV, radio, mobile communications, medical and industrial applications). Safety concerns resulting from the performance of these systems over the past two years has recently led to the declaration of a moratorium by the Department of Transportation on enforcing antikid regulations on all kinds of trailers.

A different aspect of the problem is the effect of electromagnetic radiation on living organisms. Research is going on elsewhere, coordinated by the National Telecommunications and Information Administration under a directive from the Office of Science and Technology Policy, to identify these effects and assess degrees of hazard. This subject is so extensive as to be outside the scope of my testimony except for one point. This area will also require around measurement methods and instrumentation such as that being developed by NBS in order to characterize the electromagnetic radiation environment.

The EMI problem that we are facing today is the combined result of many new sources of electromagnetic interference and many new and varied devices that are subject to such interference.

MECHANISMS AND EFFECTS

Electromagnetic radiation produces tangible and well-known effects over a wide spectrum of frequencies and is known to us as visible light, radiant heat, and, at lower frequencies, microwaves and radio waves. The last two, microwaves and radio waves, are the subject of my statement today. Though produced in different ways, all electromagnetic waves behave in similar ways. Electromagnetic radiation can be introduced into an electronic circuit by any component, such as a wire, that can serve as an antenna. A signal picked up by a piece of metal in a circuit will be conducted into the circuit and be either filtered out by certain circuit components or configuration of components or be enhanced and interacted with resident signals. This results in a disturbance to or disruption of the function of the circuit. Digital signals are disrupted by impulsive or pulsed electromagnetic signals that have compatible characteristics. Interference from stray impulses may be disastrous to digital electronics in that they insert extra digits into coded signals or cause digits to be dropped that are part of the code. Either of these effects change the coded signal and confuse the instruction or information being carried by the signal. Such effects may interrupt the function causing inconvenience or a serious complication. In a cardiac pacemaker, such a disruption to performance could, in the extreme, cause cardiac arrest. In a control to a timer on a consumer appliance it could either start or stop the process in an unintended manner.

LEVELS OF CONCERN

The sensitivity of solid-state devices is very dependent on the particular device, the technology used in its fabrication, and the material from which it is made. Therefore, it is difficult to predict levels for electronic equipment at which deleterious effects may occur. At NBS, we have observed problems in unshielded integrated circuits at electromagnetic fields as low as 1/1000 volt per meter.

The information that is known about the electromagnetic environment is relatively limited. Most of the measurements have been made with spectrum analyzing equipment that gives amplitude as a function of frequency and assume that the measuring device is in the "far field." To make this clearer, consider two zones about a radiating device. The more distant region—the "far field"—is the zone where the electromagnetic waves are essentially planar in nature and are not obstructed. This is the easiest zone for measurement and is the region where the magnitude of the electric and magnetic fields associated with the electromagnetic wave are the lowest. The zone close to the source of the radiation, the near field, is the region where measurement is the most complex and where a large percentage of the electromagnetic interference problems occur. In the near field, the electric and magnetic fields are not simply related, as they are in the far field. At the present state of the art, simultaneous measurements of both the electric and magnetic field components are technically difficult. Yet this simultaneous measurement is necessary to determine the power level. Simultaneous electric and magnetic field measurements require instrumentation that measures both field components at the same location in three orthogonal axes. NBS is studying this problem and is planning to develop the necessary instrumenta-

tion. If, in either zone, there are objects which cause significant reflections of the electromagnetic radiation, then the near-field conditions are simulated and assessment of the environment becomes very difficult (i.e., some of the objects could cause focusing, resonances, standing waves, and enhancement of the radiation).

Environmental power densities of electromagnetic radiation in broadcast and communications bands (0.5-890 MHz) have been measured by the Environmental Protection Agency (EPA) at various locations in 12 large U.S. cities. The surveys are being conducted to characterize levels in various typical environments.

These surveys are being conducted using commercially available spectrum analyzers and sensors located 6 meters above the ground (or floor). NBS has supplied experimental probes for a few special measurements of peak power. Approximately 70 percent of the sites had an average power density below 0.1 microwatts per square centimeters ($\mu\text{W}/\text{cm}^2$), and approximately 95 percent were below $1 \mu\text{W}/\text{cm}^2$. The surveys indicate that higher levels can occur in specific locations such as upper floors of tall buildings, close to radio broadcast antennas or in the immediate vicinity of mobile units. For example, levels up to $200 \mu\text{W}/\text{cm}^2$ have been measured at some locations in tall buildings. Electric field strengths to 800 volts/meter which would correspond to 170 milliwatts per square centimeter (mW/cm^2) a far field situation, have been measured in the near field in and around automobiles due to mobile radio transmitting from the vehicle. For reference, the current permissible U.S. exposure level for occupational exposure to continuous wave electromagnetic fields is $10 \text{ mW}/\text{cm}^2$. (There are no standards relating to interference with electronic devices except FCC rules regarding licensed broadcasting.)

The permissible level for interference with equipment cannot be generalized but is specific to each interfering situation.

BARRIERS TO SOLVING THE EMI PROBLEM

In order to regulate the electromagnetic environment in a rational way, we need to be able to characterize stray electromagnetic radiation. The heart of the problem, as discussed earlier, is that there is an inadequate base of measurement techniques for establishing either (a) the total (i.e., near and far field with statistical description in the important case of intermittent fields) electromagnetic environment at any point in time, or (b) the susceptibility of electronic systems to the electromagnetic environment. The technical problem includes the measurement of amplitude, phase, frequency and polarization which vary with time and position. It is necessary to develop adequate statistical descriptions to characterize these interfering fields in both the near and far fields of emitters.

There are several techniques for generating uniform levels of electromagnetic energy for testing the susceptibility of equipment to interference over limited frequency ranges and for limited applications. For example, accurate high level fields can be generated above a few hundred megahertz using standard gain horns and below a few megahertz using parallel plate lines. The major disadvantage of these techniques is that they radiate electromagnetic energy into the surrounding space which may interfere with measurements, be hazardous to the operator, or interfere with other experiments within the transmission range.

NBS has developed an improved test apparatus, the transverse electromagnetic (TEM) cell, for testing both emissions and susceptibility of equipment or vehicles to EMI. The TEM cell encloses the electronic equipment under test, and permits it to be exposed to known fields of radio frequency energy. While the equipment under test is being irradiated with continuous waves of one frequency, or with pulsed or swept frequencies, its behavior is observed for malfunction or failure. If the radio emissions of the equipment under test are to be measured, the TEM cell is operated in reverse and a sensitive radio frequency receiver is connected to it instead of a radio frequency energy source.

The cell is made of sheet metal and is relatively inexpensive. The TEM cell is a broadband device which contains the fields inside the transmission cell. Its frequency range is from zero to a wavelength which is proportional to the cell size. The fields of the empty cell vary in a reproducible and predictable way. The cell can accommodate a test electronic package of approximately one-third the volume of the upper half space without varying the electric field strength by more than 1 percent. TEM cells of many different sizes have been built to test electronic equipment; this development represents a first step in EM susceptibility measurements for small size components and systems.

As valid methods of measurement and instrumentation become available it is becoming possible to survey the electromagnetic fields and power levels surrounding those sources most likely to cause interference—that is, the high power fixed transmitters and mobile transmitters of even moderate power—and to interpret the results. It is our belief that the competence in the DoC, namely that of NBS for measurement and instrumentation and that of NTIA for telecommunications operations and spectrum management can make valuable contributions to solutions of this problem.

The general approach to designing electronics to withstand electromagnetic interference is to shield (i.e., confine the electronics to a metal box that will protect it from a selection of environmental conditions) or filter (i.e., block out the electromagnetic signals that have become imposed on the wires entering, leaving, or connecting the electronics to its component parts without impairing its normal operation) the electronics. This task can be very simple or very complicated and expensive depending upon the electromagnetic environment in which the electronics must function. Effective and reliable test methods are needed so as to assure that the operation of the electronics is not compromised or the product itself becomes prohibitive in cost. The perfection of the techniques required for evaluating the susceptibility of electronic components and systems to electromagnetic interference will produce important benefits by permitting the economical design and testing of equipment that can operate reliably in a noisy electromagnetic environment.

POSSIBLE SOLUTIONS

I believe that it is useful to make a distinction between electronic communications equipment that makes use of electromagnetic transmissions to perform its function and electronic control devices, computers and so forth that can be isolated from the electromagnetic environment. In the former, there is an intrinsic susceptibility to interference, though proper equipment design and proper management of the radio spectrum can minimize this susceptibility, whereas in the latter, proper equipment design can in general protect the components or equipment from stray electromagnetic interference if the nature of the electromagnetic environment is known.

It is clear that the electromagnetic environment must be controlled to allow effective use of communications equipment. There are established, in the federal government, agencies (FCC and NTIA) with the authority and responsibility to oversee and regulate electromagnetic radiation with respect to its interference with electronic equipment. In its work over the past 10 years in managing the use of the spectrum by federal agencies, NTIA and its predecessors have found that a systems approach is essential—that is, an approach that considers trade offs among transmitter, receiver, location, and all other components of the system. Therefore, it may be desirable to extend FCC regulatory authority to receiver characteristics. However, before any definitive steps are taken we believe that there is a need for thorough economic analyses of alternatives. In particular we note that the voluntary standards community has potential for playing an important role in this area.

There are agencies in the government (BRH, EPA, and OSHA) with the responsibility to oversee and regulate electromagnetic radiation with respect to its health effects. There are also agencies such as DoD, NASA, and DoT which by virtue of their importance, both as producers of environmental radiation and as users of radio communications equipment, have a major stake in the issue. In order to carry out their responsibilities properly, all these agencies require consistent and compatible measurement methods to determine the appropriate characteristics of stray electromagnetic radiation. The provision and coordination of these measurement methods, as I have described earlier, is the role and responsibility of NBS.

The appropriate Government role is quite different with respect to equipment such as electronic control equipment for which it may be technically feasible to provide shielding or protecting from the electromagnetic environment. In this case the burden of solving the interference problem falls more with the manufacturer of the equipment rather than through control of the electromagnetic environment. Though there are some situations where there is a special issue of safety that would fall within the purview of a government regulatory agency, this aspect of the interference problem in general involves more the private sector and voluntary standards community. Along with the provision of

appropriate measurement and test methods to regulatory agencies, NBS has a long history of close, cooperative, and fruitful relations with voluntary standards organizations.

NBS is now playing an important role in developing such test methods, such as the TEM cell discussed earlier, to test electronic control equipment for its susceptibility to electromagnetic interference.

The bill before the Committee, S. 864, deals with the important issue of whether the authority of the FCC to regulate electromagnetic radio frequency energy to prevent interference with radio communications, that is to regulate radio frequency energy to prevent interference with properly designed radio communications equipment, should be expanded to include regulation of the design of receivers with respect to their susceptibility to interference. If the Congress decides to extend FCC's regulatory authority we believe that the private sector voluntary standards community should be consulted. This would allow the proper coordination of the free marketplace for consumer home entertainment and other equipment with the rule-making activities of the FCC.

Mr. Chairman this completes my statement. I will be glad to try to answer any questions you might have.

A PROBLEM OF GROWING CONCERN: EMI

(By Frederick P. McGehan)¹

This is a sign commonly seen along highways where repair or construction is underway. It is perhaps the public's clearest indication that there is a problem called electromagnetic interference (EMI for short).

Most people are not familiar with the term EMI. However, many do know what can happen if a driver operates a mobile radio while passing through an area where there is blasting: The radio can generate a signal that triggers blasting caps on dynamite. The result can be disastrous. Hence the sign.

This is just one very small example of EMI, a problem that has been growing rapidly in the last two decades to the point that the skies over our large cities have become literally choked with electromagnetic radiation. The sources are legion: radar installations at airports, radio and television broadcasting towers, CB and mobile radios, and even sensors buried in our roadways that tell the traffic lights when to change.

The terms "electromagnetic smog" and "electromagnetic pollution" have been coined to describe the consequences of all this radiated energy. Its proliferation in our environment results in interference with all types of electronic equipment, from mammoth computers to TV sets and heart pacemakers. Where the electronic devices are used to control a vital function—such as regulation of the heartbeat—EMI can be dangerous.

The military is concerned because it uses electronic control systems in very sophisticated ways for fast, reliable control to replace or complement the trained GI. Very sophisticated display systems are often heavily supported by electronic control equipment. And among its many concerns, the military recognizes that a stray electromagnetic signal might accidentally damage or even detonate munitions.

In addition to the interference problems, there is increasing concern on the parts of the medical and scientific communities over the biological effects of this radiation on humans and animals. Initially it was believed that electromagnetic radiation produced only a heating effect in living tissue. Lately there has been evidence to suggest that there may be long-term, subtle consequences possibly involving the nervous system.

EMI problems have aroused interest in several federal agencies, including the Environmental Protection Agency, the Department of Transportation, the White House Office of Telecommunications, The Federal Communications Commission, and the Department of Defense. Many of the organizations have come to the National Bureau of Standards through its Electromagnetics Division in Boulder, Colorado, for assistance. They have come for help in determining the EMI environment and the susceptibility of individual pieces of electronic equipment to interference, and for help in finding ways to evaluate effective protection of equipment intended to prevent interference.

¹ McGehan is a public information specialist with the NBS Program Information Office in Boulder, Colo.

The electromagnetic story goes back to 1873 when James C. Maxwell, director of the Cavendish Laboratory, Cambridge University, postulated the existence of electromagnetic radiation. This theory was confirmed in 1888 by German physicist Heinrich Hertz who produced the first man-made electromagnetic wave. Succeeding inventors, most notably Guglielmo Marconi, devised equipment to generate and receive electromagnetic waves, particularly in the radio range of the spectrum. As a result, the world witnessed first wireless telegraphy and then voice transmission, which came to be known as radio.

Although entire industries were spawned by these discoveries, the amount of man-made electromagnetic radiation in the environment was relatively small until World War II. Most of the radiation resulted from radio broadcasting.

The discovery of microwaves in the 1930's, and their application to radar during the war, led to new sources of electromagnetic radiation. After the war, radar was adapted for civilian uses and microwaves were used, among other ways, for long distance telephone communication.

The development of semi-conductors, which allow more electronics to be placed in smaller and smaller configurations, added new sources of and targets for electromagnetic interference. The electronics revolution has now progressed to solid-state integrated circuitry and microprocessors that have resulted in low-priced CB radios and land-mobile transceivers and in applying control systems of difficult problems.

The consequence has been a dramatic increase in electromagnetic irradiation. At the end of World War II there were only six television stations in the country; today there are more than 1000 stations that transmit to 120 million television sets. In the same period, the number of radio broadcasting stations jumped from 930 to 8000. And a whole new era of broadcasting was ushered in with the popularization of CB radios. There are some 15 million licensed CB radios in homes and vehicles across the nation. In 1975 the Federal Communications Commission received more than 100,000 complaints concerning radio interference—and the FCC estimates fewer than one in ten interference problems gets reported. The Commission figures 9 million people will experience TV interference from CB radios in the year ending June 30, 1979.

The EMI problem promises to continue to grow, particularly in the automotive industry, as mechanical parts and devices are replaced with electronic components. A foretaste of this came in 1975 when a National Highway Traffic Safety Administration regulation required the use of anti-skid braking systems on all new trucks and buses. To comply with the stringent NHTSA regulation, the industry chose systems that are electronically controlled. Unfortunately it was found that in some cases the operation of a CB radio in the truck or bus or in an adjacent vehicle was enough to trigger the braking mechanism. Because of this and other problems, the regulation was suspended for more than a year while bugs in the new braking systems were worked out. Some 18,000 new trucks were recalled in 1975 because of the EMI problem.

Detroit has already begun introducing electronic controls—microprocessors—on selected lines of automobiles and wants to begin using them extensively within the next few years. These microprocessor-based systems will be programmed to minimize exhaust pollutants, manage fuel consumption, advance the spark, monitor safety functions, and optimize transmission shifting. In addition, air bags, which may become a mandatory safety device in future years, are triggered by electronic controls. Auto makers are fearful that their heavy investments in these new systems could be compromised by EMI. At an NBS-sponsored conference on EMI at Gaithersburg, Maryland, last July, automotive engineers called for more government-sponsored research on EMI and the electromagnetic environment in which vehicles operate in order to avoid over-designing their new electronic control systems and to assure their safety for public use.

Another recommendation made at that conference was for the increased development of modern measurement methods to compare the performance of individual small electronic components to that of large integrated systems in the face of mounting EMI problems. Interestingly, NBS is developing methods to measure both the impact of components on the electromagnetic environment and of the environment on the components. And the task is not easy.

Part of the difficulty lies in the nature of electromagnetic waves and the way they propagate (transfer energy). At a distance comparatively far from the radiating source, the waves are relatively easy to measure and techniques for doing so have been known for a long time. The wave's shape is well defined

at such a distance, and, if you were standing in front of it and could see it, it would resemble a plane of material moving towards you. Measurement under these circumstances usually requires instrumentation and good practice that recognize and identify reflections from the ground and other objects that can obscure the primary signal.

However, most important in terms of EMI and the biological consequences of electromagnetic irradiation is the so-called near field. This can be comparatively close to the radiating object, say from a few centimeters or meters for a CB radio or landmobile radio up to two kilometers for a satellite tracking station. It is here that the waves have not yet formed into a pattern and measurement is exceedingly difficult. "You can't take the same kind of instruments used for measuring the far field and put them in the near field and expect to achieve meaningful results," says Charles K. S. Miller, manager of NBS' EMI measurement program.

A second difficulty in approaching the EMI problem is the sheer number of interfering signals. If the interference were caused by a single signal, "it would be easy to tackle," Miller notes. By pinpointing the frequency and amplitude of the incoming signal, it would be possible to develop a shield and provide filtering on incoming wires to protect the electronic component from EMI at any one frequency. But that is not the case in nature or in the world as man makes it. "In the living environment you have a phenomenal number of different signals," Miller says. They come from radio and TV broadcasting stations; mobile radios in police cars, trucks and cabs; marine band radios; CB radios; and even satellites. Other devices include radar sets, garage-door openers, burglar alarms, active traffic sensors, arc welding machines, electric motors, auto ignition systems, and the corona of high-voltage power lines.

Miller sees the environment becoming messier as new, consumer-oriented products come onto the market that radiate weak electromagnetic signals. He cites as examples the types of antiburglar devices for use in businesses and homes, that employ microwaves or radio waves and the new TV and electronic games. He also believes the frequency components and waveform characters of new communications systems might add complications that are not presently anticipated.

Still another difficulty in guarding sensitive electronic components against EMI is the fact that some of the equipment, particularly when used in motor vehicles, is constantly moving in and out of different electromagnetic environments. In addition to worrying about EMI from broadcasting and radar stations, designers of electronic components for vehicles must take into account such things as electromagnetic sensors buried in the roadway to trigger traffic lights. A stray signal could cause a braking system to malfunction at an intersection and place the lives of the driver and others in danger. And, in addition to planning for all current electromagnetic environments, the designer has to try to anticipate future uses for electromagnetic waves and the corresponding potential for detrimental changes to the environment.

Two federal agencies in particular, the Environmental Protective Agency and the Department of Transportation, are interested in measuring the sources and amount of electromagnetic radiation in the environment. In its efforts to protect the public from non-ionizing radiation, EPA is interested in developing a data base on electromagnetic radiation for major U.S. cities. With such a base, the agency could determine over a period of years whether the electromagnetic environment is deteriorating, and if so, by how much. The Department of Transportation is interested in measuring the EM environment around vehicles to define typical serious conditions to which automobiles will be exposed.

In its work for DoT, the NBS Electromagnetics Division perform on-site measurement studies utilizing specially designed instrumentation near vehicles that were equipped with mobile radios. The NBS measurements showed, to the surprise of the auto industry, that the near-field electromagnetic environment frequently was higher than the currently accepted U.S. Standard for EM radiation exposure. Miller believes that the seriousness of this problem will increase as manufacturers encase electronic components in plastic rather than in metal and as metal shells are replaced by plastic ones in new vehicles. Current plastics offer no shielding against EMI. High EM field levels around vehicles, Miller believes, not only endanger the functioning of electronic components but also pose potential health dangers to vehicle occupants. Ironically, he notes, some of this irradiation comes from the very CB and mobile radios the drivers use.

Working for the Federal Aviation Administration (FAA), NBS has been developing EM measurement instrumentation, methodology, and data so the FAA can determine radiation levels around antenna sites and airports and in airplanes. The FAA is interested in avoiding or minimizing EMI problems that would disrupt navigational equipment, electronic displays for instrumented landings, electronic controls on the ground and in aircraft, and telecommunications. The FAA is also concerned for the health and safety of people who use equipment that produces high electromagnetic fields. As in many other areas of EMI measurement, the expertise and equipment to make the complex measurements do not exist in private industry and can be found only at NBS.

Indeed, over the past several years the Bureau has pioneered the development of novel instruments that can measure both the electrical and magnetic fields contained in EM waves. In 1973 a group of scientists in NBS' Electromagnetics Division won an award from Industrial Research Magazine for their development of a portable probe, called an electric energy density meter, that can be used to measure EM emitted by such diverse sources as navigational systems, microwave ovens, and radio and TV transmitters.

Another notable NBS contribution has been the development of the transverse electromagnetic (TEM) cell. This, essentially, is a large "clean room" where electronic machines and components can be tested for susceptibility to known sources of EMI or for EM output. In its most recent version, NBS has constructed a TEM cell that measures three meters by three meters by six meters and resembles somewhat a large, square boiler. The cell provides a three-quarter cubic meter test volume. More precise data on a component's vulnerability to EMI can be determined in the TEM cell's controlled environment than in the outdoors where the EM environment is continuously changing and hard to define.

In the decade since NBS first conceived the TEM cell for the EMI measurements, a number of others have been constructed for use by the military as well as by private industry. AC Spark Plug, Motorola, RCA and Zenith are some of the firms that have adapted the TEM cell for their own EMI measurement and testing programs. The performance of the cell is limited by its size, and its size limits what it can test.

NBS is currently constructing an anechoic chamber at the Boulder laboratories. The absorbent material in this large room will prevent EM signals from bouncing or reflecting off walls and disturbing delicate measurements. "It's the difference between trying to take pictures in a room made of mirrors and a room with a soft, low-reflecting background," Miller says.

Because the concern over the question of "electromagnetic smog" is relatively recent, the mechanisms for defining and combating the problem are still being developed. The government needs to coordinate the activities of the nine separate federal agencies that are now involved in some aspects of regulating EMI. Another need is for a common language of EMI. "Right now there are tremendous ambiguities," says Miller, noting that a communications expert and an electronic engineer may have different and therefore confusing ways of defining the same EMI phenomenon. "We need a glossary or dictionary so we can agree on common terminology for measurements and their results," Miller adds.

The urgency of these needs may become apparent over the next few years as more and more electronic control devices are introduced and as medical science uncovers new facts about the effects of long-term, low-level exposure to EM radiation.

One area that is sure to receive attention is the workplace. Some seven million workers are exposed daily to electromagnetic radiation as it is used in various industrial processes such as curing plastic and plywood and operating large arc welding machines. In some industrial measurements taken by the National Institute for Occupational Safety and Health, the EM fields in the working place were at least as high as 2600 volts per meter (where the standard is 194 volts per meter). The fields may have been higher, but the NIOSH instruments, provided by NBS, could not measure above 2600 volts per meter.

[The following information was referred to on p. 29:]

U.S. DEPARTMENT OF COMMERCE,
NATIONAL BUREAU OF STANDARDS,
Washington, D.C., July 27, 1978.

HON. ERNEST F. HOLLINGS
Chairman, Subcommittee on Communications, Committee on Commerce, Science and Transportation, U.S. Senate, Washington, D.C.

DEAR SENATOR HOLLINGS: This is in response to a request by Senator Goldwater during the June 14, 1978, hearing on S. 864 before the Subcommittee on Communications of the Senate Committee on Commerce, Science and Transporta-

tion. He asked if the National Bureau of Standards (NBS) would supply in the form of a letter for the record its views concerning whether a mapping of the electromagnetic environment should be undertaken, and if so, by whom, and what would be the cost.

Accompanying the increasing benefits of the use of radio and microwave radiation is an increasing concern over the possible adverse effects of stray radiation or electromagnetic-interference (EMI). These adverse effects include both potentially serious biological effects (that raise important health and safety issues) and interference effects on electronic systems. Accurate data on the extent and nature of EMI will be necessary to guide the Congress, the Executive Branch agencies, and private industry in taking efficient corrective measures. A major component of this data could be provided by a survey or mapping of the EM environment.

In order to avoid duplicating efforts, it would be important that any such survey be designed to measure all of the characteristics of the radiation required by the many potential users of the data. Users would include parties interested in health and safety aspects, as well as parties interested in interference with all types of electronic systems. Further, the mapping would need to be repeated, at least in part, at selected intervals, to monitor trends in the EM environment with changing technological developments. Obviously, the results of any such measurement undertaking would have to be appropriately documented and made available to both technical and nontechnical communities. Such a survey of the EM environment in the United States would be a substantial and complicated task.

Present and past EM environment surveys have been restricted to limited areas and to limited characteristics of the radiation—essentially to average power as a function of frequency. If we are to address the needs indicated above, then the measurements will necessarily include more extensive characteristics of the radiation measured at a wide variety of locations and times. To do this in a cost-effective manner will require a carefully designed statistical sampling plan.

Most of the EMI measurement methods now in use assume that measurements are made in the so-called far field, that is in the region far from the radiating source where simplifying assumptions can be made concerning the relationship of the various components of the electric and magnetic fields to the power density of the field. However, well in excess of 50 percent of the effects on electronics and biological systems may be expected to occur in the near-field of the emitting device or in areas that simulate near-field conditions due to multiple reflection, resonant, or enhancement effects. These effects can, in fact, occur at any distance from the radiating device and are usually not recognized because equipment designed for far-field measurements is being employed. Further theoretical studies are needed to know how to deal with these complications.

The basic tasks in such a survey of the EM environment would include:

1. Definition of the characteristics of EM radiation that would have to be measured in the survey;
2. Description of the measurement process and sampling methods that would be necessary to evaluate the above defined characteristics; Development of the measurement techniques and instrumentation; Development of the display methods for illustrating the results of the EM environmental measurements (these might be simple contour plots);
3. Development of a statistical sampling plan, based on areas of EM environmental similarity according to population, industrial character, geographical type, etc.;
4. Conducting pilot field tests to validate and refine the statistical sampling plan and to test data gathering procedures;
5. Equipping mobile or remote monitoring stations as needed for complete field data acquisition; Training teams to perform the measurements; Gathering data and converting it to final display form;
6. Documentation and publication of results and the performance of periodic measurements to monitor trends.

Such a survey would be a substantial undertaking and I can only provide rough, preliminary estimates of the costs and time required. Before such an endeavor could be placed in the budget of any agency or agencies, a much more careful analysis both of the survey plan and costs would have to be accomplished and reviewed by the Administration. My rough estimates of the costs of these tasks, as keyed to the order listed above, are as follows:

Task No. 1. No substantial cost—could be performed under the current budget of the agencies that would be involved;

Task No. 2. A cost of \$750,000/year for 5 years;

Task No. 3. A team of statisticians with computer time would be required at a cost of \$850,000/year;

Task No. 4. A cost of \$2.5 million for equipment and \$500,000/year for 2 years for manpower; The task would not start until the third year of the survey.

Task No. 5. A cost of \$15 million for equipment and \$6 million/year for five years for manpower; (his estimate is subject to modification by the result of the first 4 tasks). The task would not start until the fifth year of the survey.

Task No. 6. At this time, I am unable to estimate the optimum level for a sustaining effort after the initial survey is accomplished.

Task 1 would necessarily be a joint enterprise of various potential users of the data. It would be appropriate for NBS to carry out tasks 2 and 3. Tasks 4, 5, and 6 would be better carried out by agencies that would be the prime users of the data. NBS would, of course, cooperate with and assist these agencies as needed on a reimbursable basis. The Environmental Protection Agency is at present surveying 14 American cities to determine the extent of the environmental hazard presented by EM radiation. The National Telecommunications and Information Administration (NTIA) of the Department of Commerce has begun a study of the feasibility of conducting a mapping in a coarse way by means of aircraft or satellite-borne measurement equipment. This study has only just begun and will require some months to complete. I have apprised NTIA of your interest in this matter and have their assurance that they will report to you their findings when available.

Our feeling, in short, is that a proper survey or mapping of the EM environment is an important cornerstone in laying a sound technical foundation for policy in this area. The work should be accompanied, however, by further research on possible biological hazards and by the development of standards relating to the susceptibility to EMI for electronic systems.

Sincerely,

JOHN W. LYONS,

Director, National Engineering Laboratory.

Senator GOLDWATER. Our next witness is Harry J. Dannals, president of the American Radio Relay League and publisher of a magazine called QST, which is more or less the bible of amateur radio.

Mr. Dannals, we welcome you, and you can insert your entire statement in the record or read it, either way you want.

STATEMENT OF HARRY J. DANNALS, PRESIDENT OF AMERICAN RADIO RELAY LEAGUE AND PUBLISHER OF QST MAGAZINE; ACCOMPANIED BY ROBERT BOOTH

Mr. DANNALS. Thank you, Mr. Chairman and ladies and gentlemen of the committee. We thank you very much for the opportunity to be here to support S. 864. We have already written our formal presentation. This will supplement that, and we will only refer occasionally to the document.

I would like to have you note, however, that the document which you received on Friday did not have the attachment which the latest document passed out this morning does have, and these are references to interference and the problem of interference as published in various magazines, QST being one of them.

Mr. Chairman and ladies and gentlemen, we actively support the document S. 864. Very simply, we believe that the public, the listening, viewing public, the great majority of the people in this country, deserve far more than they have received in the way of support in this particular problem.

We contend that the Federal Communications Commission does have now much of the information that it needs, and a notice of inquiry, despite all of its good intentions, will merely offer to delay some of the action that must be taken.

I would like to call attention to some publications, and one of them is very, very old, because it is more than a quarter of a century old. This document is entitled "Television Interference," published by Remington Rand Lab and produced by a man named Phil Rand, a radio amateur who at that time was Mr. Rand of Remington Rand. And this document is dated in, as I recall, 1951 or 1952, more than a quarter of a century old.

Here in Washington, D.C., a group that called itself the Washington Television Interference Committee published a document some 25 or 26 years ago with the support of industry at that time. I reference the support by Babcock Electronics, an electronics company that paid for the actual publication of this document, but this document was published more than 25 years ago. It has in it many of the photographs and so forth, which I am proud to say that our own FCC has put out in their most recent publication of last year, May 1977.

The only difference, Mr. Chairman, is that some of their pictures are in color, whereas our pictures could not be in color 25, 26, and 27 years ago.

The contention in the report by the Commission of last year on the extent and nature of television reception difficulties associated with CB radio transmissions—a document already referenced here, and excerpts I believe are already on record—indicates that the use of certain devices called filters will solve some of the problems that we face.

I have before me right here, taken from my own home, a high-pass filter. At one point in time this device cost \$4.50, when I bought it in the local radio store. I have another filter which is not shielded in a fancy can, that ran something at the time like 89 cents. It is also a high-pass filter. And in this envelope, I have a piece of shielded wire, Mr. Chairman, a piece of shielded wire about 12 inches long, which in many cases in itself, cut and put in the right places, with a few components such as this, which is a disk ceramic capacitor, or an RF choke, which is a few turns of wire around a form, would solve some of the most difficult problems of interference.

When installed at the point of manufacture, these items are just an infinitesimal part of the cost of the overall equipment. And yes, indeed, when passed on to the consumer, they will indicate some additional price on the material. And there is no question in my mind that the industry would have to do that.

I contend, however, that unless all of industry does this voluntary cooperation cannot exist. Company A will put this material in its set and produce a set which is better than Company B's. Company B will save \$1 or more on the sale price of the equipment, and pocket that amount of money, and the consumer will buy the cheaper set. This is just the nature of competition in this country.

We contend, very simply, that voluntary work has not—voluntary cooperation has not been successful. It has not been successful because these problems have been known for decades now. Radio amateurs, long before the entrance on the scene of the citizens radio service CB'ers, had to contend with this problem.

I would just like to take a moment to relate a story that happened to me as a teenager when studying my college studies at home, reading my books and having the front door knocked on by a man by the name of Officer Carey. I will never forget his name. Officer Carey was the local policeman, off watching his new television set at that time, which he had just received, and complaining bitterly about interference, and blaming me because I was a radio amateur in the community.

I said, "Officer Carey, I'm sitting here doing my homework for my college studies. I can't have my radio equipment on at this time. If you would care to see it, if you would like to go down and look at it, it has been off for hours, days, in fact." But the problem was something else. It was not my transmitter; it was another television receiver causing the interference at that time.

And while this problem has been somewhat reduced, there is still the problem of interference to equipment by its very mate, the device of some television receiver.

We contend, Mr. Chairman and members of your committee, that perhaps the word should not be "radio frequency interference," but it should be "radio frequency interception," because the only way that one can control this interference as it is now called, or this interception, would be in many cases to turn off the switch on the transmitting device. And if this were to be the case in this country, the public service by our police and fire and the messenger services and the delivery services, all of which use radio in their communications, and our broadcasting stations and our FM stations and every transmitting device would have to cut its equipment off the air, because that is the only way to insure that this problem would not continue.

Our contention is that that certainly is not the intent of anyone on this committee, certainly not the intent of anyone in this country. And yet, that is the ultimate solution, unless industry is—and I have to say the word—forced to comply with certain preventive measures. Those I have shown here are just a small indication.

I have been privileged to work as an engineer. I am a nonsalaried volunteer officer of the American Radio Relay League. My regular business is that of an electronic engineer for the Sperry Systems Management Division of Sperry Rand Corp. I have been employed by them for 27 years. In that time, I have worked on all types of electronic equipment, radars, and other devices for ships at sea, for submarines, for aircraft, and for land-based radars and other electronic systems.

In every case, the military has had very stringent requirements on the design of our equipment, in many cases to make sure that the equipment itself does not receive interference from anything where we know that there has to be a transmitting device on the aircraft, ship, or shore station; in many other cases, to make certain that the equipment itself radiates a signal which is appropriate and will not cause interference unduly.

But you must, Mr. Chairman, as you and I both know as amateurs of many years, you must transmit a signal to be heard. You must transmit a signal to create the public service that is generated by the ambulance, by the police and the fire services, who use radios to move rapidly to their appointed rounds. There is no way to turn off this equipment.

The solution must be at the source of the problem, and if we will change the word from "radio frequency interference" to "radio frequency interception," then we know where the problem is. It is the device which is receiving something that it should not receive, should never receive. The mark of a good piece of electronic equipment is not that which it receives, but in many cases that which it rejects.

The devices that we have today in electronics are very sophisticated. They all can receive quite well. The feature that the amateurs look for and buy in their equipment is equipment which rejects interference. And I'm sure that the consumers, if a device was available to them and if all devices were of a comparable price, would buy the devices that certainly did not have interference problems.

But there is no one to tell them that. Many times we learned that someone has gone to a radio store and said, I want to buy a piece of equipment that will receive no interference like my neighbor gets. And the salesman, interested to make a sale, points to the most expensive device on the shelf. And, Mr. Chairman, that most expensive device on the shelf may be not as good as the cheaper one right next to it, if someone has not taken into consideration interference at the time of design.

Now, we respectfully are concerned about the problem, and we recognize the Commission has before it some thoughts about this entire matter. We—and I listened last night to a tape recording of the June 8 meeting of the Commission and its staff, and note with great interest that there is some difference of opinion at both the staff level and the Commission level, and this is to be expected. There are people who are concerned about the price. There are people who are concerned about the product. Somewhere in the middle must be a solution.

We are actually anxious to help in any way we can, and we as radio amateurs have been working on this problem for literally years, as will be evidenced in the articles and our publications and the many words that we have written, literally from the early days of interference.

I might say that the interference problem has not come about merely since the advent of television. Those of us who were amateurs long before television came into being know that there were other types of interference. It was called BCI then, broadcast interference, broadcast interference to radio receivers in the AM broadcasting band. The problem has been with us for years, and we have tried in every way we know to cooperate with neighbors and industry, as well as Government and FCC alike, in proving that radio amateurs are responsible people.

I speak, Mr. Chairman, for those radio amateurs, members of the American Radio Relay League, and those who are not members of our organization. But all of us have the identical problem. It has created a severe difficulty in the outside world, because lately it has

obviously accentuated by the tremendous growth in the use of electronics in communications.

We contend, Mr. Chairman, that, as I heard you say, this is but the tip of the iceberg, because the greater uses of radio frequencies throughout the years and decades to come will create still more interference. And on the tape recording of the Commission's presentation on Thursday, I heard someone talk about a notice of inquiry and investigation and responses, and I heard the words "10 years."

Mr. Chairman, if we are to wait a decade longer for some form of action on this problem, which has plagued us for literally decades in the past, then I fear for the public and I fear for the users of the radio frequency spectrum in the public interest, because all of us will have severe problems, severe problems perhaps personally, in the fact that someone may get so upset that they choose to fight, argue, or whatever. And we have had cases of that, even to the point of bodily harm and property damage as a result of interference problems over which the interfering station had absolutely no control, because they did everything that was within their right to do and within the direction of the Federal Communications Commission to impose upon the users of radio transmitters.

We, as responsible radio amateurs, have done just all of those things that the Commission has recommended. We do make certain that our transmitting equipment works adequately. Our lab at the American Radio Relay League has made considerable number of tests on all types of equipment, transmitting and receiving devices.

I would contend, Mr. Chairman, that this is something on the order of the regulations that require us to have safety belts in cars. Industry did not put safety belts in cars. Industry did not put head rests on cars, until there was a concern on the part of our Government. And while I agree wholeheartedly with you and with members of your staff on the concern about regulation and deregulation, I am concerned about one other statement that I would like to make in conclusion, and that is, very simply, that deregulation to destruction is something that we cannot tolerate.

We cannot have the lack of regulation cause us to have continued problems in this very important and vital area of our Nation's communications industry. And as a final statement, we, the American Radio Relay League, are prepared to cooperate with any group that you designate or that the Commission designates, as we have through the decades past and will for the decades to come, to present our case and our aid in whatever way we can, to assist in a resolution of this problem.

We thank you very much for the opportunity to appear.

Senator GOLDWATER. Thank you for your very interesting testimony.

I have just one question. We haven't touched on stereo apparatus yet, and, of course, I happen to be a stereo nut, along with my other electronic misfortunes. In experimenting with my equipment, I find that when I use my linear amplifier on any frequency, I get interference on my stereo receiver, but I can't relate it precisely to frequency. I have to relate it to power. Would that be correct?

Mr. DANNALS. It is interesting, Mr. Chairman, that you mention that, because on Monday I received at home, as I do many publications

of our radio clubs, this one, dated June 1978, from the Hall of Science Amateur Radio Club, at the location of the New York World Fair of 1964-65 in New York City.

And in this club newspaper—club bulletin—on page 20 there is a 1-page story entitled—would you believe—“RFI filtering (stereo),” and it talked about the very problem you’re asking about and recommends—and I just quote: “The final method of RFI treatment is to install filters in the leads picking up RFI.” And then they go into a definition of devices which they recommend for this, for curing this problem.

This is dated June 1978, received at my home just this past Monday, so it is a very current problem still with us, Mr. Chairman.

Senator GOLDWATER. If you have an extra copy of that, I would like to have it. I am interested in this. Although I carefully shield my linear and transmitting line, not only here but, on my boat I get interference whenever I turn that 1 kilowatt on, everything on boat goes around, including the compass, the Omni, all of my navigation equipment.

Mr. DANNALS. I’m sure we would have a problem, too, Mr. Chairman, but we would be happy, in our labs, to help, if I can.

I would like to introduce the league’s general counsel, Robert Booth, who is also a licensed radio amateur, and has been our counsel for quite some number of years now. If there are any number of questions as to the legal aspects of the league’s involvement in this issue, he certainly can take care of it.

He has prepared a number of our statements, recently, on my behalf, a statement before the House subcommittee on the Communications Act of 1934, when we appeared last September, which addresses the interference problem, Mr. Chairman, just the same as we are addressing it here now.

Senator GOLDWATER. Just one other question related to the one I asked you. It has been charged that the enactment of S. 864, or other bills like it, could lead to the deterioration of the quality of high fidelity sound reproduction.

Mr. DANNALS. No, sir. In no way.

First of all, many of our own people in the radio community, radio amateur community, are parents and husbands and, in some cases, wives and sisters, and related to people who enjoy, to a great extent, high fidelity. The filters that are required to do the job, the electronic shielding by use of shielded wire and so forth, are not active components at some of the frequencies that are involved in the stereo work.

And I have in my home an electronic organ and a stereo set, and I’ve had to employ certain devices in my own equipment to keep my own transmitter operating legally from interfering with that equipment when my wife or other members of the family are using those devices. I have been highly successful, and I’ve had no complaints.

And unless these people are absolutely tonedeaf, Mr. Chairman—and I don’t think that’s true—they have not had any degradation in the performance of their equipment.

I contend that industry has the capability of designing into its equipment the small degree of protection necessary without adversely affecting its performance.

Senator GOLDWATER. At no great cost?

Mr. DANNALS. Yes, sir, at no great cost, when done at the point of manufacture.

Senator GOLDWATER. That has been my contention all along. In my discussions of this problem with some manufacturers—not all—they generally agree that we are talking about a small amount of money.

However, there is always the danger, if you allow anybody or suggest to anybody that they add anything to their equipment, that the price may go up. We only have to look at automobiles to see what happens, when they put in a new type of cigarette lighter or put fins on the back of their fenders.

I thank you very much, Mr. Dannals, for this very valuable testimony, and anything that you might have in the future that could help us or help the manufacturers, we would appreciate it.

Mr. DANNALS. Yes, Mr. Chairman. We note, in the schedule for this meeting, a panel discussion at the conclusion of my testimony. We, at the American Radio Relay League, would welcome the opportunity, if it is at all possible, to sit in on that panel discussion. We feel that we could very well offer something to the discussion itself.

Senator GOLDWATER. Well, you are cordially invited.

[The statement follows:]

STATEMENT OF HARRY J. DANNALS

The American Radio Relay League, the nationwide, non-profit organization of amateur radio operators with more than 130,000 members licensed by the Federal Communications Commission, welcomes this opportunity to submit for your consideration its views and suggestions in support of the objectives of S. 864, introduced by Senator Goldwater.

The League was founded in 1914 by Hiram Percy Maxim, a well-known inventor and a dedicated amateur radio operator. The League truly represents every aspect and interest in amateur radio with no limitations as to age, sex, race, or interest. The only requirement for full membership is the demonstration to the Federal Communications Commission, or to its counterpart in Canada, a knowledge of the fundamentals of electronics and wave propagation, the applicable laws and regulations, and a knowledge of Morse code. The League has participated in many hearings held by Senate and House Subcommittees considering radio and related legislation over a period of almost 60 years. Its suggestions and recommendations have been incorporated from time to time into the Radio Act of 1927 and later the Communications Act of 1934.

I have been privileged to have served since 1972 as the League's seventh President. Traditionally, Presidents have always served without salary or other material compensation. I have been a licensed amateur operator since 1946. My father became an amateur about 1910 before licenses were issued, and my two brothers and my two sons also are licensed amateurs. Ours is an amateur radio family in every sense. My profession is that of an electronic engineer with Speery Systems Management at Great Neck, Long Island, New York.

The American Radio Relay League is dedicated to the preservation, encouragement and enhancement of amateur radio in the United States, Canada, and throughout the world. The League is the headquarters society of the International Amateur Radio Union, which consists of more than one hundred national amateur radio societies throughout the world. In addition to appearing before Committees of the Congress over the years, and participating in countless rule making proceedings of the Federal Communications Commission, the League has participated in World Radio Administrative Conferences of the International Telecommunication Union and its predecessor for more than 50 years. A close working relationship has existed between the League and various governmental agencies including the Federal Communications Commission, although, at times, we have not always agreed with the Commission's actions, procedures, and inactions.

Amateur radio operations are uniquely and eminently qualified to discuss the subject of radio frequency interference, including its causes and cures, as such interference is as old as radio itself. Without exception, the early radio inventors and pioneers were radio amateurs. The sophisticated communications systems, techniques, and equipments of today have amateur radio as their starting point.

Radio frequency interference (RFI) arises when a signal radiated by a transmitter is picked up by an electronic device in such a manner that it prevents the clear reception of another and desired signal or causes malfunction of some electronic device other than a receiver. Almost any transmitter of any service is a potential interference source. Interference problems are not limited to Amateur or Citizens Band (CB) stations.

Particularly since the advent of commercial television immediately following World War II, amateur radio operators and the League have been active in interference control and elimination. The amateurs learned very early that the incorporation of good engineering practices in their transmitters, such as electrostatic shielding and filtering, minimized the possibility of interference by preventing the radiation of spurious signals. Such practices and techniques are well understood and are universally incorporated in almost all transmitters manufactured and in use today, irrespective of the service. Appropriate rules of the Federal Communication Commission requires all transmitters of all services, including the transmitting sections of transceivers, to adequately suppress spurious radiations.

It was evident from the very outset that most of the interference problems were not with the transmitters but with the receivers and other electronic devices picking up unwanted signals.

Interference to television reception can be divided into the following causes. First is the pickup of a spurious signal having a frequency within or close to the band or frequencies occupied by the television signal. Such interference usually is caused by the interfering transmitter. In many instances, there is a harmonic relationship between the transmitter frequency and the television channel. This is particularly the case with the 27 Megahertz CB service; the second harmonic of the 27 MHz signal falls in Channel 2 and the third harmonic falls in Channel 5. Second is the overloading of the input circuit of the television receiver by an undesired signal so strong that overloading i.e., malfunctioning, of the circuits generates spurious signals within the television receiver. Such interference usually is more severe with transistorized sets and results from poor circuit design. Third is the pickup of an undesired signal by circuits within the set or wiring leading to the set. Poor shielding or poor circuit design usually is the culprit.

Interference to other electronic devices such as record players, hi-fi amplifiers, electronic organs and public address systems usually arises from the pick-up of a relatively strong signals by the external wiring, such as the wires leading to the speakers or to the power source, followed by the rectification of the signal by a circuit, contact or component within the device.

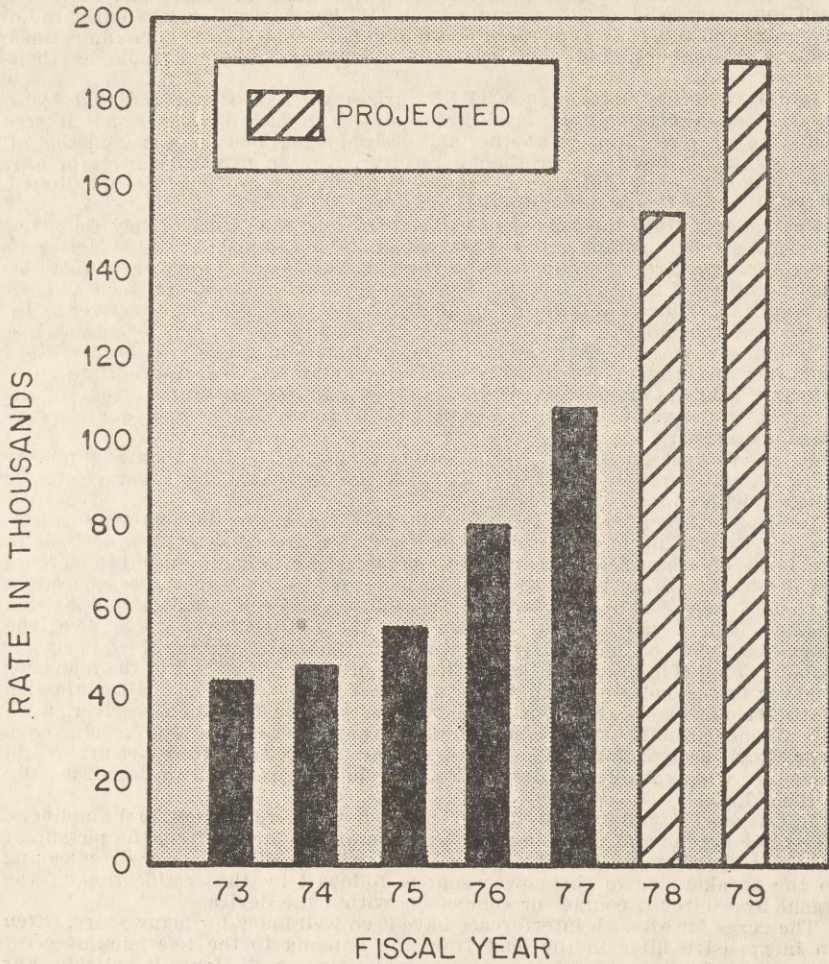
The cures for all such interference have been well know for many years. Often an inexpensive filter in the lead from the antenna to the television receiver will reduce the interference to an acceptable level or eliminate it entirely. For the other electronic devices, usually the judicious installation of two to perhaps as many as eight capacitors, each costing ten to fifteen cents at any radio store and less than one cent to a manufacturer, will suffice.

A bibliography of articles on interference published in the League's monthly journal, *QST*, is attached as Appendix A.

The Federal Communications Commission recently published an excellent booklet on causes and cures of interference to television which is available from the Government Printing Office. The title is "How to Identify and Resolve Radio-TV Interference."

Even though the causes and cures of radio and television interference (RFI and TVI) have been known for many years, the number of complaints received by the Commission have grown steadily each year. The following graph, based upon Commission figures of complaints to it, represents only the tip of the iceberg:

INTERFERENCE COMPLAINTS RECEIVED



The following statement appears in a report published by the Commission in July, 1977, "The Extent and Nature of Television Reception Difficulties Associated with CB Radio Transmission" (Report No. FCC/FOB/PD&E 77-02):

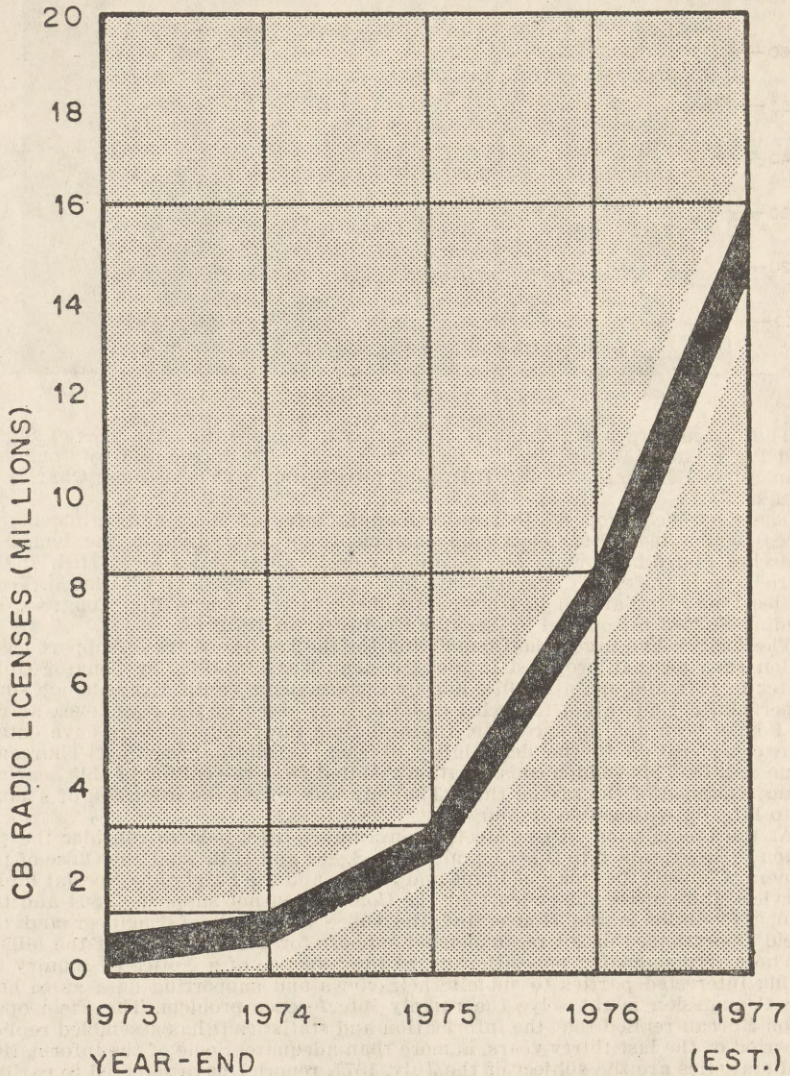
"In Fiscal Year 1976, a lower bound on the number of individuals experiencing interference to TV reception associated with the operation of CB stations probably lies somewhere between one and ten millions person, with the best estimate being four million persons. Projections for Fiscal Year 1979 are that between 3-21 million persons (best estimate—9 million) will experience TVI associated with CB radio operation."

Those estimates are limited to interference to television from CB stations and do not include radio, hi-fi amplifiers and other electronic devices.

With the rapid, and indeed explosive, growth of the 27 MHz CB service, the probability of a home entertainment device being located near a transmitter

of some sort has increased substantially. The following chart, taken from the same Commission report, shows graphically the growth of the CB service:

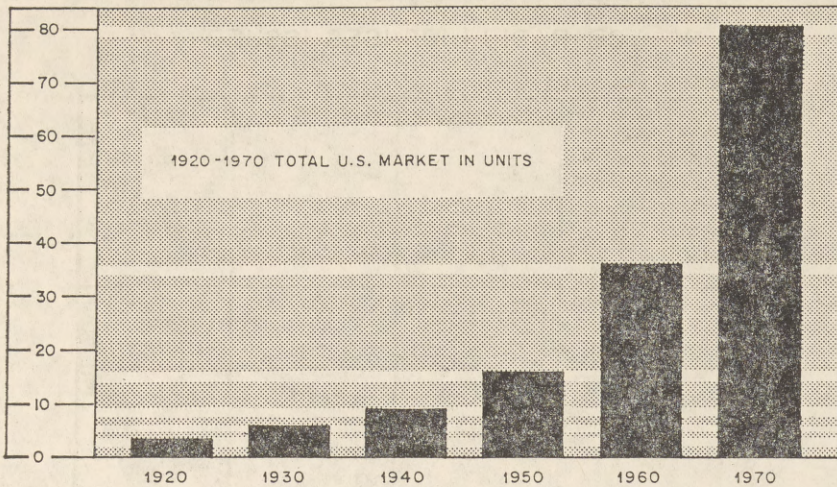
CB RADIO LICENSES ISSUED



The public's use of home entertainment devices has grown, and continue to grow, at a fantastic rate. The following chart, taken from the 1978 Annual Review of Consumer Electronics, depicts the growth in the consumer electronics market:

MILLIONS

TELEVISION, RADIOS, PHONOGRAPHS & TAPE EQUIPMENT



The League urges enactment of legislation to achieve the objectives of S. 864 and the related bills pending in the House, H.R. 8079 introduced by Congressman Adam Benjamin, Jr. and H.R. 8496 introduced by Congressman Charles A. Vanik.

The first such proposal to require manufactures of home entertainment devices—which means all electronic equipment normally used in the home, in churches and other public places, and on or in automobiles—was H.R. 16916, introduced in the 92nd Congress (late in 1972) by Congressman Charles M. Teag. At least one similar bill has been introduced in each succeeding Congress, including S. 3033 introduced by Senator Goldwater in 1976.

The League has urged the Commission for the last six years to support legislation such as that proposed by Congressman Teag in 1972, by Senator Goldwater in 1976 and again in 1978, and by Congressman Vanik. Even though some superficial consideration to such legislation was given at the staff level, as far as I have been able to ascertain, the first time the Commissioners gave extensive consideration to the desirability of such legislation was last Thursday, June 8, 1978. This sudden consideration resulted from the calling of this hearing. I am reminded of the saying that "The only way to get the attention of a mule is to hit him with a two-by-four."

At the Commission's Open Meeting on June 8, 1978, held to consider the position to be expressed to this Committee on S. 864 and H.R. 8496, the Office of the General Counsel, the Office of Plans and Policy, and the Safety and Special Radio Services Bureau recommended that the Commission not support S. 864 and the companion bills in the House, and the Office of the Chief Engineer and the Field Operations Bureau recommended support for the objectives of the bills.

Those recommending opposition urged the issuance of a Notice of Inquiry inviting interested parties to submit their views and supporting data as to how the Commission might solve the rapidly interference problem. The Field operation Bureau replied that the information and statistics it has assembled replied a period of the last thirty years, is more than adequate. Some of the information and statistics are the subject of the July, 1977, report I have referred to earlier. The Office of the Chief Engineer was concerned over the availability and cost of an elaborate laboratory and equipment and the manpower required to develop standards and to conduct type acceptance on so many devices. The statement of Chairman Charles D. Ferris represents the positions expressed by at least a majority of the Commissioners.

I am extremely disturbed by the inability of the Commission to come forward with a comprehensive set of recommendations for specific legislation and plans for its implementation. The proposal that a Notice of Inquiry be issued may be likened to "fiddling while Rome burns".

"Jaw boning", suggested by those who spoke at the Commission's meeting in opposition to S. 864, simply will not work. The home entertainment and consumer electronic market is so price-competitive that most manufacturers, even some of the largest and best known, simply will not spend the additional few cents necessary to produce interference-free equipment. Nor will an educational campaign produce more than superficial results.

The manufacturers know that the Commission does not now have authority to compel the use of good engineering practices in equipment which does not emit radio frequency energy sufficient in degree to cause harmful interference to radio communications. The manufacturers and retailers also know that the Commission cannot require a label on equipment or the supplying of a pamphlet warning of the possibility of interference and outlining corrective measures. The Commission, or some other agency, must be given the authority to require that receivers and other electronic devices be so designed and constructed as to reject interfering signals and energy.

The League's extensive experience over the years with interference investigation and elimination supports the conclusion that, in most instances, satisfactory corrective measures can be simple and inexpensive. Major modifications and redesigns of equipment now being manufactured seldom will be required. The likelihood is that elaborate and costly test facilities and procedures will not be necessary either at the manufacturers' plants or at the Commission.

The millions of purchasers of television and radio receivers and other electronic devices each year deserve more consideration than they have received so far. Enactment of legislation such as S. 864 is necessary to supplement other consumer protection statutes.

The League does not suggest any particular revisions of S. 864 at this time. After the views of other parties have become known and have been studied, we would appreciate the opportunity to submit specific suggestions.

One recommendation I do make is that this Committee require the Commission to submit at a reasonably early date a comprehensive report of what it has done and is doing to achieve the objectives of S. 864 and the companion bills in the House. Otherwise, it will be necessary to again apply the two-by-four to the mule. I suggest a date of four months from today, with a supplemental report two months thereafter.

On behalf of the 350,000 amateur radio operators of the United States, I thank you very much for the opportunity to participate in this hearing.

APPENDIX

QST REFERENCES TO INTERFERENCE REDUCTION

In addition to the comprehensive technical data contained in the ARRL Handbook, the following selected QST references will prove valuable in interference-elimination procedures.

TVI COMMITTEES—PUBLIC RELATIONS

- TVI Patterns, P. 43, May 1949.
- TV Interference Problems (Kiser), p. 45, Feb. 1950.
- Dallas Plan for TVI (Skelton and Shook), p. 26, June 1951.
- Dayton Plan for TVI, p. 34, Sept. 1951.
- FCC's Plan for Handling TVI (Turner), p. 22, Jan. 1952.
- TVI Committees (Editorial), p. 9, Feb. 1952.
- Letter to TV Receiver Manufacturers, p. 35, Feb. 1952.
- On the TVI Front (Club Reports), p. 26, Mar. 1952.
- Letter from TV Receiver Manufacturers, p. 27, Mar. 1952.
- 21-Mc Letter to TV Manufacturers, p. 30, June 1952.
- On the TVI Front (VHF Heterodyne TVI), p. 44, June 1952.
- TVI Report to Manufacturers (Rand), p. 47, Aug. 1952.
- On the TVI Front (TVI Causes), p. 53, Sept. 1952.
- On the TVI Front (TVI Committee Plan of Attack), p. 52, Dec. 1952.
- Progress Report on TVI Committees (Turner), p. 48, Feb. 1953.
- Handling TVI Complaints Due to Poor TV Sets (Shook), p. 51, June 1953.
- Color TV and the Amateur (Grammer), p. 31, Nov. 1953.
- Channel Strip TVI (ARRL Letter to FCC regarding 2-meter TVI), p. 45, Nov. 1953.

- Spurious Radiation Problems, p. 31, Jan. 1954.
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 Progress and Activities Report—Washington TVI Com. (Richman), p. 52, July 1954.
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 On the TVI Front (Guidance Material for TVI Committees), p. 61, June 1955.
 On the TVI Front (Revised Roster of TVI Committees), p. 54, Sept. 1955.
 Incidental and Restricted Radiation Devices, p. 32, June 1956.
 List of TVI Committees, p. 51, Oct. 1956.
 The Amateur and Public Relations (Richman), p. 82, May 1959.
 TVI Committee Operation (Heller), p. 56, Feb. 1967.

SHIELDING AND TVI-PROOFING TRANSMITTERS

- TVI Tips, Shielded Hook-up Wiring, p. 45, Aug. 1949.
 Shielding for TVI Reduction (H & K), p. 118, Oct. 1950.
 TVI-proofing the ARC-5 VHF Transmitter (Johnson), p. 50, Nov. 1950.
 Simple Experimental Shielding (H & K), p. 66, Dec. 1950.
 Chasing TVI Out of the BC-610 Transmitter (Harlow), p. 65, May 1951.
 Curing Industrial TVI (Rand), p. 29, Sept. 1951.
 TVI Treatment for "Command" Transmitters (H & K), p. 66, Apr. 1952.
 TVI-proofing the Viking I (Rand), p. 20, June 1952.
 Home-built Shielded Link (H & K), p. 63, Aug. 1952.
 Source of Shield Cans (H & K), p. 66, Sept. 1952.
 Improved Shielding with Copper Screen (H & K), p. 68, Dec. 1952.
 Fishbox Shielding (H & K), p. 69, Dec. 1952.
 Electronic Weatherstripping as an Aid to Shielding (Schreiber), p. 29, Aug. 1953.
 Another Inexpensive Source of Shields (H & K), p. 50, Sept. 1953.
 Suppressing TVI in the Meissner Signal Shifter (McCoy), p. 33, Oct. 1953.
 Operating the BC-696 in TV Fringe Areas (Ticen), p. 22, Dec. 1953.
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 Design of Low-Pass Filters (Seybold), p. 18, Dec. 1949.
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 Eliminating TVI with Low-Pass Filters, Part II (Grammer), p. 20, Mar. 1950.
 Eliminating TVI with Low-Pass Filters, Part III (Grammer), p. 23, Apr. 1950.
 Low-Cost TVI Filters (Dene), p. 16, May 1950.
 By-Passing for Harmonic Reduction (Grammer), p. 14, Apr. 1951.
 Low-Pass Filter for High Power (Fosberg), p. 28, Oct. 1951.
 Low-Cost Low-Pass Filters from Standard Mica Condensers, p. 39, Dec. 1952.
 Tin Can Low-Pass (McCoy), p. 29, Sept. 1954.
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 Harmonics, Harmonics, Harmonics (McCoy), p. 16, May 1960 (Feedback, p. 29, 1960).
 Low-Pass Filters And Spurious Radiations (Kuper) (TC), p. 43, Oct. 1960.
 How to Attenuate Your Harmonics (McCoy), p. 41, May 1961.
 Low-Pass Filter for 6-Meter Operation (Lange), p. 23, June 1961.
 How to Avoid Radiation of Spurious Signals (McCoy), p. 26, Apr. 1962.
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Senator GOLDWATER. So, let me ask Mr. Edward Day, special counsel of the Consumer Electronics Group, Electronic Industries Association; Mr. Paul Berman, on behalf of the Association of Maximum Service Telecasters; Leonard Feldman, well-known technical director of the Institute of High Fidelity; and Mr. Edward Foster, consulting editor of High Fidelity magazine—which, I might add, I just finished reading a recent copy of last night, and I saw the very interesting cartoon of me in it, which I will have framed; and Mr. John Hannold, consulting editor of Stereophile magazine; and John Jarrett, from Alexandria, Va.

Gentlemen, please be seated. I don't know who wants to be the leadoff spokesman in this group. We will point the finger at you. You are always good enough to volunteer.

STATEMENT OF J. EDWARD DAY, SPECIAL COUNSEL, CONSUMER
ELECTRONICS GROUP, ELECTRONIC INDUSTRIES ASSOCIATION

Mr. DAY. I wouldn't ordinarily volunteer to be first, Senator, but there has been an awful lot of talk today about the manufacturers of consumer electronics products. I speak on their behalf and I want to emphasize that we have been doing a great deal and are doing a great deal and are intensely conscious of this problem and have not been sitting back waiting for a kick in the pants from the FCC or from anybody.

Our association represents manufacturers of all types of consumer electronic products, including television receivers, radios, phonographs, audio systems, and tape recorders. We represent not only substantially all of the domestic manufacturers of television receivers, but we represent some of the leading manufacturing companies from Japanese origins who now have manufacturing facilities in the United States: Panasonic, Sony, Sanyo, and many others in the nontelevision field.

Under existing sections of the Communications Act, as you know, the Commission does have authority to regulate the manufacture, sale, and use of devices which have the potential for causing harmful interference. As a matter of fact, the regulation over the manufacture of such products only came into law 10 years ago. Before that the FCC jurisdiction was only on use and sale.

I want to respond, just briefly, to a question that Senator Schmitt asked of the Bureau of Standards, because we do have a lot of information about the situation on imports. Our association is certainly not against imports, but, so far as I know, there are no home radios made in the United States anymore. Also practically no tape recorders are made in the United States. Most all of your stereo equipment is made abroad, and that is true of the majority of your black-and-white television receivers, and also of many of your color television receivers.

We are very anxious that nothing should be done by way of legislation that would seem to represent a conclusion from the Federal Government level that there is a shortcut, easy solution to the interference problem. We think the public should not be led to believe that, by something new being done in the regulatory field, the problem can be solved.

We think that the FCC already has a great deal of authority that relates to possible solutions to part of the interference problem, and we think that they should more fully exercise that existing authority in the interference area before new legislation is enacted.

Just as an example, there is a very complex rulemaking proceeding going on before the FCC at the present time, relating to a decrease in the permissible level for harmonic radiation from CB radios. We think the existing permissible level is much too high. That is a thing that I think has not been discussed here, specifically, this morning. You are very familiar with it. And that is that where it is a harmonic coming in on the same frequency as a television channel, there is no way to do something inside the television receiver that is going to solve that. That is because if you have something filter out that form of harmonic interference, it will filter out the program you are trying to receive since it comes in on just the same frequency. And some of the

harmonics from CB and other sources do come in on some of the frequently used VHF channels. So, we feel on that subject there really is nothing the manufacturers could do.

We have done a great deal in the way of bringing into the designs of new color television receivers engineering changes that reduce interference.

In the study by the Field Operations Bureau of the FCC which has been referred to this morning, there were not enough new sets involved in that study, newly designed sets, very recent designs of television receivers, to permit an adequate reflection of the changes that have already been made in television receivers.

That is a most important study. It involved going into randomly selected neighborhoods in six metropolitan areas and studying, in depth, interference complaints. We have some differences of opinion with the interpretation of that study. Mr. Ferris gave a figure that the FCC thought possibly as much as 40 percent of the interference cases could be improved by something that could be done to the television receiver. We think it is closer to 20 percent.

I don't think anybody denies, however, that the FOB study confirmed that excessive harmonic radiation from CB transmitters was found to be the major cause of television interference.

The statistics out of that study are a little bit confusing because many of the cases involved interference from a number of sources. Television interference from CB transmitters was, by far, the biggest percentage figure, but sometimes when the television receiver was being interfered with, there was also interference with the stereo or with some other product in the same house.

We think that the figure that the FCC gave as to the cases where there was excessive transmitter harmonic radiation should be adjusted upward. They said 55 percent. We think it should be even higher, because of the FOB study, the cases that involved linear amplifiers gave rise to a considerable number of complaints per individual case.

Now, the FCC not only has been doing a number of things, has a number of things pending, and has the authority to do more, but also, they have new legislative authority that Congress just gave them last February, and that is increased enforcement powers and increased penalties. That just same in under a law that is often called the "pole attachment bill" that was passed and enacted in February. That bill was preceded by statements by the then Chairman of the FCC that one of the reasons they needed greater enforcement authority and greater authority to impose larger penalties was because of this problem of violations, both in CB's and in illegal use of linear amplifiers. And they have been taking steps to improve their enforcement on that subject.

Up to now, I would say their enforcement has been about like trying to enforce the prohibition law with six prohibition agents. They have not accomplished very much.

Mr. Dannals said the interference problem was like the auto seat-belt situation. But interference is not a safety problem; it is a performance problem. We have, in this business, particularly in the audio field, we have the equivalent of Mercedes limousines and we also have the equivalent of Volkswagens and Pintos, and we think there should be a continuation of those difference in product because this is one of

the most impossibly competitive businesses from the standpoint of price squeeze that exists.

I would say interference is the second biggest problem of the consumer electronics industry. Our first biggest problem is survival at all. You may have seen in U.S. News and World Report, in a recent issue, they listed a whole number of products and what has happened to their prices. On all of them, they had gone up, except for two: television receivers and bedsheets—those two had gone down.

And our prices are actually too low. We point out in our prepared statement the relationship to the Consumer Price Index. It is unbelievable how the prices of television receivers have remained down. So, even a few dollars in increased cost is something that has to be reckoned with in this business.

Now, you heard from the NBS. We have been working closely with them, working on methods of measurement, working on this TEM cell matter. We have a committee in the EIA that has been assigned no responsibility but this interference problem for a long period of time.

We put out to service technicians detailed books on how to go about coping with interference problems, both with television and with audio equipment.

We think, therefore, Mr. Chairman, that it is unnecessary to pass new legislation. We don't say that from the standpoint of stubbornness or unwillingness to do things. We think it is very much like Mr. Ferris said. There is nothing that can be done overnight. There are already 130 million television receivers out there in use, and, fortunately, they are a longlasting product. There may be 15 million CB's out there that were manufactured before even the inadequate existing harmonic radiation requirements.

You can be assured from us that we are going to continue to give this matter urgent attention, and we are going to do what can be done as a feasible matter, both technologically and economically. But we can't promise the problem can be wiped out overnight.

Thank you.

Senator GOLDWATER. Thank you.

You made one statement that I would like to challenge and then ask for any comments from the other panel members. It refers to harmonics. In using just the amateur bands, when we get up to the CB frequency—28,000 megahertz and 29.7—we find harmonic interference on channels 2, 6, 7, 10, 11, and 12. Yet, on meters, or 7 megahertz, we get 8 harmonics, and that is way down below, on 2, 3, and 4. The 28 to 29.7 is second and third. Sixth and seventh cause all of the troubles.

Now, is it the general feeling among the people here that harmonics do not bother television reception?

Mr. FOSTER. No, Senator. I think that harmonic radiation from the transmitter is probably the cause of a good bit of television interference—if the harmonics lie in the television band, as specifically with the citizen-band radios, they do. If those harmonics are going generated in the transmitting equipment and are not adequately suppressed at the transmitter, no amount of filtering at the television set is going to help. And I think that was Mr. Day's point.

If, on the other hand, the television set is overloading because of very high radiated power, then filtering at the television set may help to reduce the problem.

So, I think you get the same sort of effect on a television set from two different physical conditions, and I think it is simplistic to think that filters only at the television set will solve all problems, or, for that matter, that filters at the transmitter will solve all problems.

Senator GOLDWATER. What would happen if we moved CB to 432 mega-liberty?

Mr. FOSTER. We would have good television reception.

Mr. DAY. Perhaps we would have a revolution. The CB people are pretty powerful.

Mr. FOSTER. In point of fact, in the FCC study, I saw no evidence of CB interference with UHF television, because the UHF televisions use such a high frequency.

Senator GOLDWATER. That is true.

Mr. FOSTER. So, movement, in part, if that is feasible—

Senator GOLDWATER. Would 430 interfere with UHF?

Mr. FOSTER. I'm not sure about the UHF band, Senator.

Mr. DANNALS. Yes, sir, it is possible.

The point that we'd make, and the reason I said this, radio amateurs do not want to give up a frequency band at 432 megahertz, exactly as we did in the case of class E at 220 to 225. Others of EIA have argued that point many years back and months back.

What has been stated by the gentleman to my left, Mr. Foster, is true. Absolutely, in the case of transmitters that are transmitting high harmonic content. Our contention is today that almost every radio amateur has been forced, in order to live with his own family, to make certain that he has installed the proper filters on his equipment, and beyond that, even shielded and filtered all input and output leads from his radio equipment. He has done far more at far greater expense because of power levels involved in some cases that require componentry of greater costs in order to make the filters, he has done far more on his side of the fence than has industry on its side, with all due respect to Mr. Day and industries concerned.

I am happy to see that industry is still investigating the problem, but, Mr. Chairman, we don't see action. That is the only contention that we have.

And my point about seatbelts was not to, in any way, bring about a discussion of safety versus seatbelts in automobiles and hi-fi sets. It was to bring out the point that until the Government took an active concern, industry would just as easily have not put anything on the car. Now, they have passed that along to me, the consumer, and you, the consumer, and I anticipate that Mr. Day's organization—not Mr. Day, because he's not in the industry itself—but the industry itself will have to add costs.

But the public will be served by this additional cost, if it is done across the board, with everyone. And that is the only way it can be done.

Senator GOLDWATER. Well, is there anything wrong with our suggesting to the newly formed group that makes linears.

Mr. DANNALS. ARMA?

Senator GOLDWATER. Yes; suggest to them that they incorporate a filter in each linear amplifier.

Mr. DANNALS. In almost every case, Mr. Chairman, the transmitters manufactured for use in the amateur service today do have built-in

low-pass filters and line filtering and filtering of various leads in and out. This also goes for transceivers.

Mr. FOSTER. Mr. Chairman, the FCC study stated that the linear amplifiers had substantially more harmonic radiation than straight CB units without linear amplifiers.

Mr. DANNALS. Mr. Chairman, I would like, very simply, to answer that.

All of the CB amplifiers used in the CB service, not one of them was approved, and they were all illegal. And the proof that we have is that investigating some of those—and by amateur laboratories—we have found that they are “the dirtiest” amplifiers in existence and should not be compared at all with amateur radio amplifiers. The CB amplifiers were the quickest pile of parts that could be put together to amplify a signal and, in some cases, without any concern as all about what came out, even if less power came out than went in.

[The statement follows:]

STATEMENT OF EDWARD DAY, COUNSEL, CONSUMER ELECTRONICS GROUP OF
ELECTRONIC INDUSTRIES ASSOCIATION

The Consumer Electronics Group of the Electronic Industries Association (EIA/CEG) represents manufacturers of consumer electronic products such as television receivers, radios, phonographs, audio systems and tape recorders. We represent substantially all of the domestic manufacturers of television receivers and also some of the Japanese manufacturers which have facilities in the United States.

Under existing Sections of the Communications Act, the Federal Communications Commission has authority to regulate the manufacture, sale or use of devices which have the potential for causing harmful interferences. Sections 301 and 302. Actually, the authority to regulate the manufacture of devices which could cause interference was granted to the FCC just ten years ago in new legislation which is now 302a. We believe that the FCC should more fully exercise their existing authority in the interference area before more new legislation is enacted.

Various proposals for using this existing authority have been or are now pending before the FCC. Also, as we will point out, the penalties available to the FCC in its enforcement activities were greatly increased just a few months ago, and there has been little chance to see in practice to what extent these higher penalties will impact the interference situation.

Consumer electronic manufacturers have responded and are responding positively to the interference problem.

Nothing should be done which would seem to represent a conclusion from a federal government level that there is an easy, shortcut solution to the interference problem. Because there is no easy solution—and the public should not be led to think there is. In our opinion new legislation is not necessary and definitely not appropriate.

Manufacturers of consumer electronic products have compelling economic incentives, without additional regulation or legislation, to do whatever is feasible to attack the interference problem. Interference complaints and poor performance hurt sales. Competition provides a powerful incentive to minimize the susceptibility of audio devices to radio frequency interference (RFI). The consumer electronics industry is subject to intense competitive pressures and a long-standing profit squeeze. The performance of the prices of television receivers, for example, in relation to the Consumer Price Index, is startling. Television receivers entered the Consumer Price Index in 1950 at 159.7. The average for all items that year was 72.1, based on a 1967 standard of 100. By the end of 1977, the Consumer Price Index for all items had risen to 181.5, but television receivers had dropped to 101.7. During this period, many technological advances were made which greatly enhanced the quality, reliability, safety and energy efficiency of television receivers. There is a similar pattern for other electronic entertainment products.

DESCRIPTION OF THE INTERFERENCE PROBLEM

Millions of different radio signals are being emitted every day at legally prescribed frequencies. The receiving unit, such as a television or radio receiver, attempts to discriminate among these many different signals and the one it was intended to receive. However, the television or radio receiver sometimes picks up not only its intended signal but a strong (usually nearby) signal from some other source such as a citizens band ("CB") or amateur radio transmitter.

This unwanted signal either interferes with television picture quality or is received over the sound system of the receiver on top of the regular program. Virtually all forms of audio devices are subject to this kind of interference, including radios, phonographs, tape recorders, organs and intercoms. This type of interference is commonly known as "audio rectification," and may be heard as intelligible voices or music; as garbled voices; as a buzz or hum.

NO SIMPLISTIC SOLUTION TO THE INTERFERENCE PROBLEM IS AVAILABLE

From various sources there have been efforts to oversimplify the causes and solutions for the problem. Usually, these oversimplified approaches have resulted in claiming that the problem could be solved by requiring electronic entertainment products to have additional shielding or filters so that the interference would be rejected.

For some time, the Federal Communications Commission (FCC) sent form letters to persons sending in complaints about television receivers claiming that if they received unwanted CB transmissions on their television sets, the fault was not really with the CB transmitter but with the fact that the television set was not designed with the proper circuitry to filter out the CB signals.

Television manufacturers countered that this simplistic approach was all wrong—that the fault usually is not with the television receiver but with the fact that interference is caused by practices which create unwanted signals that the television receiver cannot be expected to discriminate against.

The FCC has completed an in-depth study of CB interference to TV reception in 72 randomly selected neighborhoods located in six metropolitan areas. The study shows the relative impact of various interference causes. The sum of the causes identified by the study does not add to 100 percent because many cases could be resolved by more than one action and many cases exhibit overlapping causes.

Excessive harmonic radiation from the CB transmitter was found to be the major cause of television interference. A harmonic is a multiple of a fundamental signal which appears as a weaker signal. Because some harmonics have the same frequencies as some of the television channel frequencies, television receivers cannot distinguish between and separate the desired program signals and the interference signals.

The FCC study indicates that approximately 36 percent of CB-TV interference complaints were attributable to TV receiver overload, but it should be borne in mind that this included cases where illegal high wattage linear amplifiers were involved. There is no such thing as an "interference-free television receiver" and it is not simply a matter of cost. The FCC found that excessive transmitter harmonic radiation existed in 55 percent of the RFI cases investigated. This percentage should be adjusted upward to reflect the fact that in the FOB study the cases involving linear amplifiers generated a considerable number of complaints per individual case. The 55 percent figure, from a meaningful standpoint, is therefore too low.

A study by the Advanced Development Laboratory at the GTE Sylvania Entertainment Products Group Headquarters of television interference caused by CB radios supports the conclusions that harmonic radiation is the most significant cause of TV interference.

CB transmitters can be properly shielded, filtered, designed and operated to have low harmonic output.

The FCC study also concludes that the use of linear amplifiers was associated with 46 percent of all TV-CB interference cases. The study estimates that elimination of linear amplifiers would resolve 25 percent of all CB-TV interference problems and substantially improve an additional 20 percent of the cases, possibly to the point of not being objectionable. Because high-gain directional antennas or linear amplifiers greatly increase the area affected by a CB station, the study estimates that greater controls on such radiated power could eliminate approximately 50 percent of all interference complaints. Thus, the majority of RFI

resulting from CB is due to excessive harmonic radiation from CB transmitters or the illegal use of linear amplifiers. Studies by the television manufacturing industry indicate that less than 20 percent of cases of interference to television reception could be cured by an additional filter on the television receiver.

In the report of the Field Operations Bureau, there is data on the age of the television receivers involved. However, there were not enough new receivers in the total to make possible arriving at conclusions about the effect of recent changes the manufacturers may have made.

Television receiver manufacturers had no crystal ball that would have allowed them to predict the phenomenal upsurge in CB popularity that began in 1975. In response to the explosion of CB usage, the television receiver manufacturers examined the input filtering on their receivers and the field complaints that could be corrected by additional filters. Additional filters were added to many models in order to deal more effectively with RFI produce by CBs.

Amateur radio transmitters can also be a source of interference to television reception. Amateur radio transmitters operate with several orders of magnitude more power than CBs. There are, however, approximately 320,000 amateur radio stations as opposed to over 11,000,000 CB operators. Amateur radio operators, therefore, will cause interference to far fewer television receivers. Manufacturers have a very low incidence of this type of complaint and, in those instances where complaints have existed, the technical skill and expertise of the amateurs have enabled manufacturers to work effectively with them in resolving interference problems.

Due to the much higher power output of amateur radio transmitters and the fact that interference from amateur transmitters may occur on a number of frequencies, only relatively expensive filters (on the receivers) can deal with this problem. As explained earlier, even increasing the use of filters will often fail to solve the problems.

Filters are not a panacea. It would be very expensive, and perhaps impossible technically, to require all electronic devices to include filters capable of dealing with the situation in which one has an amateur radio operator in the next apartment. The consumer would end up footing the bill of any such grandiose scheme. Given the relatively small number of amateur radio operators and the small number of complaints of interference from this source, it is much more efficient to provide extra filters in those few cases in which an actual problem arises from amateur radio transmitters.

Up to now, where owners of television receivers write to the manufacturer complaining about interference, the manufacturer will usually furnish an additional filter, at no cost or nominal cost to the owner. (It is important to note, however, that follow-up on these cases where the additional filter is furnished confirm that less than 20 percent of CB interference cases are, in fact, solved by the additional filter.) As manufacturers have redesigned their receivers they have taken advantage of the opportunity to include additional filtering and improved design to increase interference immunity.

As stated earlier, interference complaints and poor performance hurt sales. Competition provides a powerful incentive to minimize the susceptibility of audio devices to RFI. The current utilization by the consumer electronic manufacturers of additional filters is but one example of the effectiveness of this incentive. Dealing with RFI involves general care in engineering the entire audio device. Manufacturers are continuing this process of product improvement in order to further reduce the susceptibility of their equipment to interference.

Illegal, high-power CB transmitters have been the major source of "audio rectification" interference to audio products, radios and, in some cases, television. Manufacturers have responded to the problem by making minor changes in their products that represent good engineering rather than excessive cost of additional components. Manufacturers do extensive laboratory and field testing to ensure that RFI will not degrade the performance of their products. Products are continually reevaluated to improve performance. The rarity of complaints of RFI in the absence of illegally amplified, or improperly designed, CB transmitters demonstrates the success of our members' engineering efforts.

However, the public has a large number of products made before audio rectification was a problem. Solving this type of interference complaint is more difficult and expensive than interference to the television picture because the modification usually has to be made inside the product. Further, internal modifications may cause a shock or fire hazard and may jeopardize a product's Underwriters' Laboratories (UL) listing unless performed by a qualified service technician following the manufacturer's instructions.

In those cases in which RFI does degrade product performance, most manufacturers will continue to assist their customers.

In addition, most manufacturers of electronic entertainment equipment take other steps to cope with complaints of interference received from owners of their products. With some companies, assistance is provided in determining the origin and cause of the offending signal; if the problem is found to be the result of a performance deficiency within the product, technical assistance is provided to the owner's service technician in correcting the problem or the product is returned to the factory for modification at no (or just shipping) expense to the customer if the product is considerably outside the warranty.

EIA/CEG has developed two technical handbooks on the subject of radio frequency interference for use by service technicians. These handbooks provide both general information on the nature of such interference and specific remedies for reduction of interference effects on audio, radio and television equipment. Fifty thousand copies of the handbook on "Television Interference" have already been distributed free to service technicians, and 110,000 copies of the handbook on "Audio Rectification" have been so distributed. Copies of each handbook have been sent to 1,100 television and radio stations.

In addition, EIA/CEG member companies have published their own booklets to assist service technicians in diagnosing and dealing with interference problems with television receivers, radios and audio equipment.

EIA/CEG for several years, through its Director of Consumer Affairs, has assisted Congressional offices in investigating and attempting to resolve interference complaints.

Manufacturers have been working closely with the National Bureau of Standards (NBS), Boulder, Colorado, where work on methods of measurement for determining the susceptibility of electronic products to RFI is done. The TEM cell, developed by NBS, is the most promising method of measurement available today; however there is still much further work to be done to extend the upper usable frequency range of the large cell needed to test a television receiver. Several television receiver manufacturers already have TEM cells and use them as part of their work on new products. Several more have plans to construct or acquire TEM cells. Undoubtedly, other manufacturers will acquire cells once the development is complete. EIA/CEG has encouraged the FCC to acquire a TEM cell so that they might become more familiar with this method of measurement.

EIA/CEG for several years has had an engineering committee concerned solely with the problems of interference, or more properly, electromagnetic compatibility. This committee is a forum and a means of disseminating information relating to methods of measurement of susceptibility to RFI.

LEGISLATIVE ACTIVITY

The Communications Act of 1934, as amended, in Section 302a, gives the FCC jurisdiction to make reasonable regulations governing the interference potential of devices which, in their operation, are capable of emitting radio frequency energy in sufficient degree to cause harmful interference to radio communications. The Act gives the FCC authority to levy forfeiture penalties, or civil fines, on violations of the Act or of the Commission's rules or regulations under the Act. The FCC had requested Congress to enlarge the scope and to increase the effectiveness of the forfeiture provisions. In 1977, Honorable Richard E. Wiley, then Chairman of the FCC, testified to the Subcommittee on Communications of the Senate Committee on Commerce, Science and Transportation, that expansion of the FCC forfeiture authority over unlicensed operators was necessary for effective enforcement, especially in view of the increasing use of the CB radio service. The Senate Committee agreed in Senate Report No. 95-580, which accompanied S. 1547, in which the Committee endorsed, for example, greatly increased maximum amounts for the forfeiture penalties, and extension of the period within which notice of liability for violations of the Act must be sent.

Because unrealistic and inadequate penalties existed, and because both the FCC and Senate Committee believed that forfeiture penalties were the most effective sanction, such changes were necessary to achieve, in the words of the Senate Committee, "more effective deterrent levels of forfeiture authority." The House incorporated the expanded forfeiture provisions in H.R. 7442, and on February 21, 1978, they were enacted as amendments to the Communications Act of 1934.

Use of illegal linear amplifiers is one of the violations of the Act for which the recent amendments will provide more effective enforcement. The increased maximum amount recoverable as forfeiture penalties will provide a greater sanction and have a stronger deterrent effect on this major source of interference than provided by the previous, inadequate forfeiture provisions. Moreover, the increased period in which notice of apparent liability for violations must be issued will allow the limited number of enforcement staff more time to review possible violations.

EIA/CEG is convinced that neither legislation of the type referred to or any other legislation relating to interference problems is necessary or appropriate. We feel that the FCC now has the statutory authority it needs and that, subject to the limitations of its inadequate funding and staffing, the FCC is moving ahead with grappling with the interference problem.

The greatly increased forfeiture penalties and revised procedural requirements for imposing them were enacted to improve enforcement and deterrent effectiveness. There has not been time as yet to test the effect of the new forfeiture penalties, and action on Senator Goldwater's bill should be delayed until the effect of the higher penalties can get observed in action. At all cost, legislation should be avoided which contemplates simplistic regulatory solutions which are not consistent with the technological realities.

FCC ACTIVITY

The FCC has recently voted to prohibit the manufacturing, importing, or marketing of any linear amplifier which is capable of being used with a CB transmitter, even if minor modification of the amplifier is required for that type of use. This ban includes any amplifier which can operate on any frequency from 24 to 35 MHz. This action was taken due to the large number of interference complaints which the FCC had traced to the illegal use of a linear amplifier with a CB transmitter.

In addition, the FCC has ordered, for three years, type acceptance of all linear amplifiers capable of operation below 144 MHz which are manufactured, marketed, or imported for use in the Amateur Radio Service. Type acceptance is an FCC equipment approval which is granted to a manufacturer and which signifies that a particular type of equipment has been evaluated by the FCC and found to be capable of complying with all applicable regulations. Mandatory type acceptance was ordered, like the ban on certain linear amplifiers, because of the continued manufacture and illegal use of these amplifiers by CB and unlicensed operators. The regulations do not include amplifiers capable of operation above 144 MHz, since they cannot be operated with a CB transmitter.

While the FCC had periodically reported crackdowns on a few CB operators for using illegal amplifiers, effective enforcement had proved almost impossible. The above FCC regulation have become effective as of April 28, 1978. These regulations, in conjunction with the recently amended forfeiture provisions of the Communications Act, should prove to greatly reduce violations from this major source of interference.

Recently, the FCC has reported criminal enforcement activity relating to illegal linear amplifiers.

Other current FCC activity has a bearing on the overall problem. This includes the following:

(1) The Federal Communications Commission's Report and Orders on Citizens Radio Service: Docket No. 20120—CB Transmitters, and Docket No. 20746—CB Receivers, adopted July 27, 1976, will make some contribution to the reduction of citizens radio service interference to home entertainment equipment and other services in the future. Immediate relief to CB interference problems caused by harmonic and chassis radiation will not be forthcoming, as there are currently over 15,000,000 CB transmitters and/or transceivers in use to which the new regulations would not apply.

(2) CB transmitter harmonic radiation specifications, adopted on July 27, 1976, are minimal. Tightening of harmonic radiation from 60dB to 100dB is proposed in Docket No. 21000. The FCC should require more harmonic suppression so as to protect television reception at 100 to 200 feet from the offending CB transmitter. We are concerned by indications that the FCC may not intend to promulgate a decision on this issue. This may carry an implication that the FCC thinks illegal linears are the core of the problem and that no FCC action is needed except enforcement action against illegal amplifiers. The FCC analyses indicate that with 60dB harmonic suppression the interference range of a legal CB

transmitter is 1,080 feet (330 meters) when the desired television signal is strong (at the Grade A contour). With a fringe television signal (at the Grade B contour), the interference range increases to 3,600 feet (1,096 meters). This problem can only be solved at the CB transmitter.

In connection with this Docket No. 21000, the Consumer Electronics Group, with the assistance of the EIA Communications Division, has completed a test program designed to yield meaningful information on sources of harmonic radiation from CB transmitters. The test results indicate that radiation directly from the transceiver cabinet, as opposed to via the antenna, is a much more important source of RFI than was previously thought to be the case. Since the filters which CB transmitters are currently equipped with are not capable of attenuating harmonic radiation directly from the transceiver cabinet, this new study may demonstrate the need for improved engineering design of CB transmitters.

In October 1975, the General Accounting Office issued a report to Congress entitled, "Actions Taken or Needed to Curb Widespread Abuse of the Citizens Band Radio Service." This report discussed interference with television reception caused by violations of applicable regulations by CB users.

RFI can be reduced in an effective, equitable and efficient manner. Illegal usage of amplifiers on citizens band radio transmitters can be curbed by the FCC if a real effort is made to enforce the law.

CONCLUSION

EIA/CEG urges that the Congress refrain from considering or adopting legislation on the subject of interference.

Senator GOLDWATER. All right. You are free to talk, Mr. Feldman.

STATEMENT OF LEONARD FELDMAN, TECHNICAL DIRECTOR, INSTITUTE OF HIGH FIDELITY; ACCOMPANIED BY ROBERT L. GUR-ARIE, EXECUTIVE DIRECTOR, INSTITUTE OF HIGH FIDELITY

Mr. FELDMAN. My name is Leonard Feldman. I am technical director of the Institute of High Fidelity. We are an association of some 40 small- and medium-sized high fidelity manufacturers, all of whom are dedicated and devoted to the audio science and art.

Essentially, I would like to address—the point that you raised a moment ago, and I was happy to hear that you are a stereo fan. Some time ago I published an article in *Radio Electronics*, which I will be happy to let you have, which details some 10 filtering points where one might try to apply filters to within a receiver, or a stereo receiver—and that is only the receiver. We're not talking about the problems of interference in tape recorders and phonograph pickups and microphone channels and so on.

Incidentally, I think part of the problem here is that the proliferation of CB's in the past 5 years is much more of a factor in all of this than the discussion we have been having about amateur radio. I think we are in full agreement on that.

Because prior to that, of course there was always a neighbor of an amateur radio operator who was very close by and might, on occasion, be interfered with. However, the real problem has come to light in the past 5 or 6 years with the proliferation of CB's.

In any event, from the point of view of the manufacturers that our association represents, we are talking about possibly 10 or 12 filter points in the receiver. We are talking about eight types of multicomponent filters. And I don't think it is a bit oversimplistic to suggest that a small capacitor or small inductor put at a judicious point inside a receiver is going to cure the ills.

Senator GOLDWATER. Does this include the television set receiver and the stereo receiver?

Mr. FELDMAN. No; I am addressing my remarks primarily to the stereo problem—the high fidelity audio problem—which of course our manufacturers are deeply involved in.

In any event, if you add all of this up in terms of dollars and cents, it is far from a \$1 or \$2 situation. If you were to apply all these filter possibilities—and in my own experience as an electronic engineer of some 30 years, and I do run a laboratory myself, besides my work for the IHF—I have found that one can't always pinpoint the place where the filter must be inserted.

So in theory, with the kind of legislation that is being suggested here, it could come about that we might be required to add all of these filters in all of these possible places and still not come up with a 100-percent total solution. Such an addition might well represent a significant increase in cost to our type of product which prides itself as being a counterinflationary product, in the sense that our high fidelity equipment is actually less costly today for better quality than it was 5 to 10 years ago.

So we feel that such legislation might contribute to an inflationary trend. But more importantly, as I mentioned at the outset, we are concerned with quality of sound reproduction.

And the FCC's own booklet—which I think you have a copy of there—I think in a way substantiates some of what I'm saying. It does suggest a variety of possible filters that might have to be tried. And what is worse, it places some of those filters in circuit positions which would definitely degrade the performance of the product which we are trying to upgrade.

As an example, it suggests putting a capacitor across the phono input circuit. As you know, this would alter the response of the pickup cartridge—something we would obviously be violently opposed to.

And so our people take the position that such legislation is not called for, and might hurt our industry.

Thank you very much.

Senator GOLDWATER. I imagine the better the equipment, the more complicated becomes the filter requirements. Is that right?

Mr. FELDMAN. That could be so. The more sensitive, the higher gain the equipment has—as, for instance, in the magnetic phono circuit, which puts out a very small signal, we have to have a lot of amplification, and it would therefore be more susceptible to what we, by the way, call audio rectification.

In answer to your earlier question: It is not a frequency problem, it is a power problem in the case of audio equipment such as audio amplifiers.

Senator GOLDWATER. In the case of a receiver?

Mr. FELDMAN. There it could be either, or both. If it is getting in through the phono section of the receiver, it is strictly a power problem.

Senator GOLDWATER. How about harmonics, relative to AM or FM?

Mr. FELDMAN. There, it could be frequency problems.

Senator GOLDWATER. Well, that is very interesting. I have read a lot of articles you've written.

Mr. FELDMAN. Thank you, sir.

Senator GOLDWATER. I make my own stereo equipment, so most of my problems are myself.

Mr. DANNALS. Mr. Chairman, we agree that there could be the possibility of multiple points of filtering. I contend that Mr. Feldman certainly has done far more, perhaps, in studying the insides of a high fidelity setup than I have. But I also know that there are filtering and shielding techniques that can be incorporated at the time of manufacture which are considerably easier to do than the description of the after-the-fact installations, as described in the FCC book.

The FCC book is what you and I can do at home with our hands after the equipment is in front of us, not what can be done at the point of manufacture. And I think there is much in the ingenuity of industry to devise different ways of filtering.

It is not necessary, for example, for a television manufacturer, or a high fidelity manufacturer, to use the type of sheet metal work that we must use in our transmitters. He can get away with, in some cases, merely tinfoil properly laminated on some kind of a wood base. I have seen this accomplished, and it works.

Senator GOLDWATER. I want to remind you gentlemen that our bills—and Congressman Vanik is here, now—address the major problem millions of persons experience. They don't seek 100 percent elimination of the problem; only a substantial reduction.

As I said at the outset, I don't think there is any way yet devised to control harmonics at the source until you can get at the rascal where he is born. You can talk all night about it. So keep that in mind.

Even if you do this in a cooperative way, while your goal can always be perfection, you probably will not reach it.

[The statement follows:]

STATEMENT OF LEONARD FELDMAN, TECHNICAL DIRECTOR OF THE INSTITUTE OF HIGH FIDELITY

Mr. Chairman, my name is Leonard Feldman, and I am Technical Director of the Institute of High Fidelity (IHF). With me today is Robert Gur-Arie, the Executive Director of IHF. The IHF is a trade association comprised of some 40 leading small- and medium-sized manufacturers of high fidelity equipment, all of whom are dedicated and devoted to the audio science and art. We appreciate your giving us the opportunity to comment on S. 864, and we hope that you and the members of your subcommittee will take our views into consideration.

I would also like to state that in addition to being Technical Director of IHF, I am an electronic engineer by training, with nearly 30 years of experience in the audio and high fidelity industry. I own a laboratory in which I test and evaluate much of the high fidelity and stereo equipment offered to United States consumers. I also write about stereo and audio in several nationally distributed periodicals and in audio trade journals.

The members of IHF are opposed to S.864, and I will attempt in this brief presentation to tell you why. We do not believe that S. 864 will achieve its objective of eliminating radio frequency interference, and we fear that the ultimate result of the passage of S. 864, or similar legislation, would be both a substantial increase in the cost of high fidelity equipment and a possible deterioration in the performance of that equipment.

While Radio Frequency Interference, or RFI, in audio equipment can be caused by a variety of sources, such as amateur radio operators, paging systems, TV stations, and even X-rays, diathermy equipment and neon signs, the tremendous increase in RFI observed in recent years has been largely due to the proliferation of citizen's band radio, popularly called CB. In many cases, illegal use of CB equipment, which is operated at power levels beyond authorized limits, causes the problem. But even CB equipment operated legally can create a phenomenon known as audio rectification in sensitive circuits commonly found in high fidelity equipment such as audio preamplifiers, amplifiers, tape recorders and receivers.

In an article which I wrote for Radio-Electronics and which appeared in the March 1977 issue of that publication, I said, "Interference from this group

(radio or TV stations, amateur radio operators, CB operators, paging systems) will prove more difficult to diagnose, because its point of entry into an audio device can be anywhere from the antenna to the speakers. Interference can be picked up by long connecting cables acting as antennas or a component acting as a detector, or it may be transmitted through AC power lines, especially if the source of interference is in the same building as yours."

In that same article, I went on to indicate no fewer than ten locations in a typical audio receiver that might require any one of eight different multi-component filtering networks to eliminate the common forms of RFI. Furthermore, even if all of these proposed filter networks were designed into an audio receiver, there is no guarantee that they would eliminate every form of RFI to which such equipment may be susceptible. And finally, even if we conservatively estimated the cost of each of these filters (including parts, labor and overhead at the factory level) to be \$2.00, we are talking about an added cost, at factory level, of some \$20.00. Translated to retail levels, such additions might well end up costing the consumer between \$60.00 and \$100.00 in added price. Typically, stereo receivers in this country popularly sell for as little as \$200.00 to \$300.00, so we are talking about a penalty of as high as 50 percent of the cost of such a receiver.

It should be added that the high fidelity industry is one of the few industries that has not had an inflationary spiral. Today, prices are equal to or lower than prices 10 years ago, and the product quality has improved during that period of time.

I am certainly not alone in discussing possible solutions to RFI. In May 1977, the Federal Communications Commission published a 33-page booklet entitled, "How To Identify & Resolve Radio-TV Interference Problems." Beginning on page 14 of that publication, the FCC suggests almost as many possible solutions to the RFI problem as I did in my article. At least two of these solutions, however, would degrade the high fidelity performance of the products involved. Specifically, the FCC suggests that all speaker wires from audio equipment leading to loudspeaker terminals should be shielded. As anyone familiar with high quality audio amplifiers knows, such shielding procedures will add high amounts of electrical capacitance to the audio output circuits and might well cause the amplifier to become unstable. This in turn can lead to failure of the product and even burn-out of the associated loudspeakers.

The goal of the high fidelity industry is to produce equipment which faithfully reproduces music in the home. On page 15 of the FCC booklet, a suggestion is made that a device known as a capacitor be wired across the input terminals of the "offending" equipment. Applied to the phonograph input terminals of a high fidelity stereo amplifier, such an addition might well alter the accurate response capabilities of the product and turn a hi-fi product into a low-fi product.

IHF does not believe that every purchaser of an audio component should have to bear the cost of including multiple filters and/or shielding in high fidelity components when a large percentage of purchasers will never experience any interference problem and when it is clear that only a small percentage of interference problems can be avoided by the incorporation of such elaborate filtering and shielding. Furthermore, because much of the RFI problem is caused by inadequately designed CB transmitters and by the illegal use of high powered amplifiers which are added to legal CB equipment, we believe that efforts should be made to correct the problem at the CB level.

IHF is convinced that legislation such as S. 864 is neither necessary nor appropriate. We feel that the FCC has the authority it needs to deal with the interference problems arising from the recent proliferation of CB equipment. Our member manufacturers are keenly aware of RFI and have for some time been studying and incorporating circuit modifications which reduce this form of interference without sacrificing high fidelity performance or unduly increasing the cost of their products. The high fidelity industry has invested much research talent, time and money in continually improving the performance and quality of the products it offers to consumers. Governmental action should not be allowed to impose requirements that would degrade the performance and unnecessarily increase the cost of high fidelity equipment, negating improvements in the state-of-the-art and leaving American consumers dissatisfied with new products.

In conclusion, the Institute of High Fidelity is opposed to S. 864 and urges you and the members of your subcommittee to vote against its approval.

Mr. Gur-Arie and I shall be happy to answer any questions you may have.

Senator GOLDWATER. Congressman, would you like to testify now?

Mr. VANIK. Whatever is your convenience, Mr. Chairman.

Senator GOLDWATER. I have to go speak to some Republican women at 12:30.

So you go right ahead.

**STATEMENT OF HON. CHARLES A. VANIK, U.S. REPRESENTATIVE
FROM OHIO**

Mr. VANIK. Mr. Chairman and members of the panel, of course I very much appreciate this opportunity to address this issue. I want to tell you that I have had more correspondence on this issue than I've had on the tax reform program, or on the economy in general.

It is a tremendous outpouring of people that are concerned. And while the FCC talks about 100,000 complaints, I think there is an infinitely greater number of complaints—and we don't get all of the complaints, particularly since they have eliminated the process of taking them by telephone.

Now I would ask, Mr. Chairman, that my statement be introduced into the record as submitted.

I simply want to condense it. And I think that the requirements in receiving complaints are far too complex. People are much more apt to call their Congressman than they are to deal with the FCC.

So I think that when you measure the complaints on the interference problem, you have to see what 535 Members of the Congress have been receiving on this whole issue.

Now our legislation would reduce by about half the source of the complaints. In 1977, that would have eliminated about 1.4 million instances of frequency interference. I think the projection for 1979, as you have said, Senator, is in the neighborhood of 7 million.

Now Congressman Van Deerlin and Congressman Frey have introduced the Communications Act of 1978, and have included a provision for the Commission to study the problems related to the susceptibility of consumer electronics equipment. And I simply want to say that both our legislation encompasses all visual and electronic equipment.

And I would like to—if my statement is in the record as submitted, Mr. Chairman—I would like to say that we expect to move forward on the House side.

This is a very serious problem. We think a tremendous portion of the American population is deeply involved in the problem. And I think it is time that we take this legislative action to produce results.

I want to, before I close, Senator, I want to commend you for your leadership in this very vital matter. And it has certainly aroused, and has the interest, of practically everyone that is using the media.

And now that on the House side, we are broadcast throughout our full session, and we will soon have television from beginning to end, and there may be some interference that would be helpful for us, but I certainly don't think we want to count on that as a way of diffusing the truth of the proceedings. I think everybody wants a clear picture. Everybody wants clear sound, and they are entitled to it. And I think it is time—the time is now for taking legislative action to bring it about.

I want to express my appreciation to the panel, and I want to say that after this is printed up, or during the transcript period, I certainly want to analyze the statements that you've made, and I certainly would like—Mr. Chairman, if you would permit—I would like to have the opportunity to individually write to any of the panelists on any questions that I felt were unanswered during the course of the panel discussion, so that both my question and answer might be inserted in the record.

Senator GOLDWATER. Fine.

[The statement follows:]

STATEMENT OF HON. CHARLES A. VANIK, U.S. REPRESENTATIVE FROM OHIO

Mr. Chairman and members of the subcommittee, I greatly appreciate this opportunity to address this subcommittee on a serious, growing problem in the area of personal-use radios and broadcasting equipment. In the past year, the Federal Communications Commission has received approximately 100,000 complaints about interference to audio and visual electronic equipment caused by a wide variety of legally operating broadcasting sources, including CB radios, microwave ovens, and automatic garage openers. The number of complaints has increased approximately 150 percent since fiscal year 1973, with projected complaints reaching 110,000 by fiscal 1980. These figures represent only a small portion of persons whose home entertainment devices are actually affected by radio frequency interference. Studies by the FCC report that for every RFI complaint received, there are 14 other people in the same neighborhood being annoyed by the same interference problem. Clearly, this problem warrants the immediate attention of the Congress.

I have introduced legislation again in this Congress (H.R. 8496), which would eliminate almost 50 percent of the incidences of such interference. My bill would authorize the FCC to establish minimum standards for the electronic rejection of RFI in televisions, radios, and other audio and visual electronic equipment. Unlike my legislation in the previous Congress, this new bill permits individual manufacturer to develop their own solutions to reject interference from unwanted, but legally operating sources of radio frequency interference.

Almost all of us have experienced radio frequency interference to our television or radio. Suddenly, strange voices or statics will interrupt a television show or even block out the picture and sound altogether. RFI can also affect stereos, hi-fis, electrical musical instruments, and public address systems. The entire range of audio and visual electronic equipment is susceptible to such interference. Reports have been received of RFI affecting braking equipment and airport traffic control centers. Even vital health and life-saving devices, such as pacemakers, are dangerously vulnerable to RFI.

It would seem only natural that a new television or radio set should work properly. In fact, however, the Federal Communications Commission has found that approximately 90 percent of these interference problems are not caused by the improper operation of a transmitter, but are due to the inherent inability of various home entertainment devices to adequately reject unwanted signals. The receiving unit indiscriminately picks up radio signals that are in the atmosphere in addition to the desired signal. As a result, the competing signals block each other out, causing interference to the desired program. As home electronic entertainment equipment has become more popular, and as electronic equipment has begun to use less shielding and more solid state circuitry, the equipment has become increasingly susceptible to such interference.

In many instances, the installation of a simple filtering device is all that is needed to eliminate RFI. Other times, more complicated remedies are needed. However, the average television buyer does not possess the technical expertise to deal with this problem. In an informal survey my office recently conducted of 20 area television repair shops, most had never heard of the filter commonly used to rectify RFI problems. Two shops carried the necessary high pass filter; however parts and labor totalled between \$15 and \$25, a considerable expense after investing \$300 or \$400 for a television. It would be much simpler, more efficient, and less costly for the manufacturers to install the appropriate filtering device when the set is first assembled. The cost, after mark-up would be minimal, and much cheaper than the cost of a later service call. In many instances, simple

design corrections, such as shortening or shielding antenna leads, can insulate entertainment equipment from RFI.

The electronics industry has been very reluctant to attempt to correct this problem. In a short survey I conducted several years ago, some manufacturers stated that they have incorporated a device in the manufacture of their sets that incidentally has some rejection capabilities. Of course, those whose equipment already rejects unwanted radio signals would not be affected by my legislation since their equipment would already meet standards that would be established by the FCC. It appears that manufacturers respond to customer complaints on an individual basis. However, due to the confusion over the causes of RFI, the uninformed customer is much more likely to blame his broadcasting neighbor than to contact the manufacturer of his set, which is exactly the case in most instances of alleged ham radio operator caused interception.

The phenomenal growth of radio signals in the atmosphere has caused a new form of electronic "pollution". The popularity of CB radios, in particular, has increased the incidence of RFI problems by placing legally operating broadcasting units more and more frequently within the "interference range" of susceptible televisions and radios (the FCC reports approximately 83 percent of television interference is associated with CB radios). This problem is particularly aggravated in the cities and suburbs, where one source may conflict with many receivers in a congested radio signal atmosphere. An entire community in my district was affected by one apparently legally operating source. In another instance, my office was contacted by the Connecticut state police because their broadcasting equipment was interfering with local television reception. The FCC was unable to be of assistance in these cases simply because it does not have the manpower to investigate each complaint it receives. (FCC field personnel numbered 488 in 1947; in 1976, there were 492 employees responsible for monitoring and investigating all RFI complaints). Processing of complaints with form responses alone costs the Federal Communications Commission over \$1 million per year. Also, the FCC only has the authority to regulate the broadcasting unit, it has no jurisdiction over the quality of the receiving units.

As we become increasingly dependent upon electronic equipment communications for both business and pleasure, it is vital that the equipment we rely upon is equipped to function in the congested atmosphere in which it must operate. I hope this Subcommittee will give careful consideration to the legislative initiatives introduced to solve this growing RFI problem.

[H.R. 8496, 95th Cong., 1st sess.]

A BILL to amend section 302 of the Communications Act of 1934 to authorize the Federal Communications Commission to prescribe regulations establishing minimum standards with respect to certain electronic equipment that is susceptible to radio frequency energy interference.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) section 302 of the Communications Act of 1934 (82 Stat. 290; 47 U.S.C. 302a) is amended as follows:

(1) Subsection (a) of such section is amended—

(A) by inserting "(1)" immediately after "governing" in the first sentence;

(B) by striking out the period the end of the first sentence and inserting in lieu thereof ", and (2) establishing minimum standards for the reduction of interference from radio frequency energy to audio and visual electronic equipment."; and

(C) by striking out "shipment, or use of such devices" in the second sentence and inserting in lieu thereof "or shipment of such devices and electronic equipment or the use of such devices".

(2) Subsection (b) of such section is amended by striking out "ship, or use devices" and inserting in lieu thereof "or ship devices and electronic equipment or use devices".

(3) Subsection (c) of such section is amended—

(A) by inserting "or electronic equipment" immediately after "devices" wherever such term appears in the first sentence;

(B) by inserting "and electronic equipment" immediately after "Devices" in the second sentence; and

(C) by striking out "the common objective of reducing interference to radio reception," in the second sentence and inserting in lieu thereof "the objectives of reducing interference to radio reception and to electronic equipment,".

(b) The heading for section 302 of such Act is amended to read as follows:

"INTERFERENCE WITH RADIO COMMUNICATIONS AND ELECTRONIC EQUIPMENT"

SEC. 2. Any minimum standard established by the Federal Communications Commission under section 302(a) (2) of the Communications Act of 1934, as added by the first section of this Act, shall not apply to any audio or visual electronic equipment manufactured before the date of the enactment of this Act.

Senator GOLDWATER. Mr. Day, does the industry have any standard yet for the installation of filters in television equipment when manufactured?

Mr. DAY. Well, I'm glad you asked that question because Mr. Dannals said our industry is "studying" the problem. I said, in my brief opening remarks, that engineering changes are actually being made in the new designs of television receivers in the color end of it. This is already taking place.

There are also improvements in engineering design being made in the audio equipment, as Mr. Feldman mentioned, particularly by some of the manufacturers who have better facilities to do so.

As far as being able to have a standard that could be used in a labeling program, there isn't any way to do it now because, in order to monitor a labeling program, you have to have some objective test of what the measurement is, and whether you are complying; and that doesn't exist as yet in any workable form. That is what the NBS talked about, what Mr. Ferris talked about, and what we have in our prepared statement.

This very expensive equipment has to be perfected to make possible that type of an objective standard. But the advantage of a voluntary program—in contrast to a mandatory program—is that the consumer electronics manufacturers can go ahead, and are going ahead and doing all of these things on the basis of no particular standard of measurement as to what has been achieved, but because we know from the standpoint of the engineers that we are improving the situation. We have quite a group of engineers here from the consumer electronic industry's members, if you want to ask any of them about any of the fine points—leading engineers from RCA, Sylvania, General Electric, Electronic Industries Association—they are here.

We can make all of those engineering changes without waiting for a standard of measurement, because we know they improve things, and that is being done.

One of the things which Mr. Vanik well knows—and I'm glad he is not getting as many complaints about the post office as he is getting about interference; I thought maybe he was—but one of the things that is a problem in actually getting at the existing situation is: There is already all this large amount of consumer electronics equipment that is already out there in the hands of the public because we had no crystal ball for seeing this explosion of the CB business. And we could not foresee that the FCC would pretty much let the CB problem get away from them.

Senator GOLDWATER. Mr. Hannold has not spoken yet.

**STATEMENT OF JOHN E. HANNOLD, CONTRIBUTING EDITOR,
STEREOPHILE MAGAZINE, ELWYN, PA.**

Mr. HANNOLD. I would like to dispense, then reading my prepared statement, and point out an important distinction between S. 864 and Mr. Vanik's bill, H.R. 8496.

In your bill, and in a similar bill in the House, the FCC would be authorized to require specific filtering measures because the words you used in there are "protective components." The FCC would be allowed to require the use of protective components.

Now in Mr. Vanik's bill, in contrast, the FCC would be authorized to establish minimum standards for the reduction of interference from radio frequency energy; and it is more than a semantic difference, because it does, at least, recognize the fact that there are no curealls. Every case is different. There are differences from one circuit to another.

I think that is a very important point. And even though we are not discussing imminent legislation today, I think that the difference in approach should be noted.

Senator GOLDWATER. Well, I have a question: How would you express the standards?

You are speaking in the interest of stereo, I believe?

Mr. HANNOLD. Basically, yes.

Senator GOLDWATER. Let's say I am going to buy a piece of stereo equipment. What would I see as a standard expressed under the FCC regulations?

Mr. HANNOLD. Well, assuming that we could come up with a meaningful standard, probably a specification of the RF field strength in which a device could be expected to operate under certain conditions. For example, its location; whether or not it is connected to an external ground system; what other pieces of equipment are being interconnected, and so forth.

I will give you a good example. You can take one turntable with one cartridge in it and one preamp and have interference. Change any one of the three components, and you lose the interference. The three components, working together as a system, may interact.

A component manufacturer is in a bind trying to figure out all of the possibilities his product may face in actual use because of interactions between interconnected components.

Senator GOLDWATER. But the introduction of for example a Dolby circuit, would that cause possible interference?

Mr. FELDMAN. It could.

Senator GOLDWATER. I asked that because mine does.

Mr. HANNOLD. Well, I have a friend in California who had a Dolby circuit—and external Dolby system—and that was the only component in his system picking up interference. He had the system in a basement rec room. So he drove a pipe through the floor and into the ground and grounded the whole system the way broadcast equipment is grounded, and that cleared it up. No amount of other fooling around would do it. But putting the thing in a screened cabinet, with a good earth ground—not just a water pipe that could be corroded, but a good earth ground connection—that solved the problem.

Mr. FELDMAN. Almost any nonlinear device—and Dolby fits into that category because it is not a flat frequency response device—can be

subject to audio rectification. And there again, we get to the power amplitude problem.

[The statement follows:]

STATEMENT OF JOHN E. HANNOLD ON BEHALF OF THE STEREOPHILE

My name is John E. Hannold. I am speaking today both as an interested consumer and as a representative of the Stereophile.

The Stereophile is a quarterly magazine devoted to the interests of the high-fidelity stereo perfectionist. The most basic tenet of the magazine's editorial philosophy is that sound reproduction, especially music reproduction, should be as lifelike as possible. We and our subscribers are among the most critical and the most demanding consumers of electronic audio equipment. We appreciate the opportunity to appear at this hearing on S. 864 because we are deeply concerned by the implications of this proposed legislation.

As presently worded, the bill would empower the Federal Communications Commission to regulate the design, manufacture, and marketing of all consumer electronic equipment, including perfectionist audio equipment. The Commission would be free to require the use of whatever RFI suppression measures it saw fit, including substantial amounts of RF filtering.

Conventional RF filtering measures degrade the performance of audio circuitry. Regulations requiring specified kinds of filtering in audio equipment would result in an artificial ceiling on the quality of performance available in commercially built sound equipment.

Even with substantial compromises in sound quality, the employment of internal RF filtering could still not guarantee the consumer freedom from RFI. Susceptibility to RFI is influenced by a number of external factors, including possible interaction between interconnected pieces of equipment, the use of resonant lengths of connecting cables, or even the use of defective connecting cables, to cite only three possibilities.

The problem with all of the RFI bills now before the Congress is that they are based on the assumption that most RFI problems result from inadequacies in the design and construction of home entertainment equipment, such as television sets and audio components. In fact, it is the poor design of Citizens Band radio equipment and the prevalent use of illegal "linear" RF power amplifiers by Citizens Band operators that cause most RFI today.

The Federal Communications Commission already has the authority to regulate all radio transmitting apparatus. If that agency would adopt more stringent standards for legal CB equipment, such action would reduce the incidence of television interference by forty to fifty percent.

And if the F.C.C. would prosecute those who violate its rules for CB operation—especially the users of "linear" amplifiers—more vigorously, that would reduce the incidence of television interference by another forty to fifty percent, and it would also reduce the incidence of interference in audio systems by better than ninety percent.

The Stereophile has no direct interest in holding down the manufacturing costs of audio equipment. If the kind of mandatory filtering that would be required under the terms of S. 864 would not have any negative side effects on audio quality, we would probably endorse it, even if it were only fifty percent effective in eliminating RFI. But the fact of the matter is that such measures do affect the quality of sound reproduction.

So we oppose S. 864 and any other legislation which could place an artificial ceiling on the quality of audio equipment available to the American consumer.

[The following information was subsequently received for the record.]

JULY 6, 1978.

HON. HARRISON H. SCHMITT,
U.S. Senate,
Washington, D.C.

DEAR SENATOR SCHMITT: When I appeared as a witness before the Subcommittee on Communications at the recent hearing on S. 864, I noted that you were especially interested in the problem of interference in cardiac pacemakers caused by Citizens Band radio operation.

Although my formal testimony at the hearing dealt only with RFI in home entertainment equipment, I too, am interested in the larger question of electro-

magnetic compatibility in all kinds of electronic equipment, including medical electronics.

I would like to bring to your attention two items of information from government publications that, taken together, clearly indicated the potential for interference to pacemakers from CB equipment long before any actual cases were reported.

The Air Force tested the susceptibility of pacemakers to RFI in order to assess the hazards posed to pacemaker patients by high-powered radar installations. It was determined that pacemakers were generally affected by E fields of 10 volts per meter (10 V/m) or more.

Air Force work in this area was summarized in "Fourth Report on 'Program for Control of Electromagnetic Pollution of the Environment: The Assessment of Biological Hazards of Nonionizing Electromagnetic Radiation'", published by the now-defunct White House Office of Telecommunications Policy in June, 1976.

In that same month, the FCC issued a report entitled "Interference Problems Associated With Proposed Expansion of the 27 MHz Citizens Radio Service Band" (FCC/OCE LAB 76-02), which included field strength measurements on CB gear.

A legal CB transmitter, with output power of four watts or slightly less, was connected to a simple, non-directional antenna (a 5/8 wavelength groundplane antenna) mounted at a base height of 25 feet.

At a distance of 25 feet, the measured field strength was 2 volts per meter; at 50 feet, 1.1 V/m; and at 200 feet, 0.22 V/m.

To put this into perspective, let's consider what would happen if either the transmitter power or the antenna efficiency were increased.

The use of an illegal "linear" RF power amplifier could easily increase the field strength at 50 feet to 11 volts per meter (somewhat above the 10 V/m interference threshold established by the Air Force) with the same modest antenna used in the FCC test.

The use of a more elaborate antenna, a highly directional multi-element antenna, for example, could also greatly increase the range at which a field strength of 10 V/m or more could result with only four watts of power from the transmitter. The use of a "linear" amplifier in conjunction with an elaborate directional antenna could easily produce such field strength levels at distances of up to several hundred feet.

But even those factors do not fully define the scope of the problem. It is extremely difficult to make accurate "near field" measurements with the test equipment currently available.

For an excellent discussion of that aspect of the problem, I would recommend the statement presented to the Subcommittee on Communications at its hearing on S. 864 by Dr. John W. Lyons of the National Bureau of Standards. The section under the heading "Levels of Concern" (pages 4 through 6) deals with this area in some detail.

I hope this information will prove helpful to you.

If I can be of further assistance to you, please do not hesitate to contact me.

Very truly yours,

JACK HANNOLD,
Contributing Editor, The Stereophile.

Senator GOLDWATER. Mr. Berman, you have not spoken, yet.

STATEMENT OF PAUL BERMAN, ESQ. ON BEHALF OF THE ASSOCIATION OF MAXIMUM SERVICE TELECASTERS, WASHINGTON, D.C.

Mr. BERMAN. I represent the Association of Maximum Service Telecasters, which is an organization of 200 television broadcast stations interested in maintaining and advancing high technical quality television service to which the American public is entitled.

We have participated actively in many, many FCC proceedings concerning interference to television reception. In reviewing the particular problems you focused on today, Mr. Chairman, we share Mr. Day's view that this legislation may not be appropriate, because it might

suggest that there is a simple, federally mandated solution applicable in all of these cases.

But our concern is much broader than the subject discussed today. In particular, the letter that you read into the record from Mr. Travis Marshall of Motorola indicates that although there is dissension within Motorola as to whether the FCC ought to adopt receiver standards geared to citizens band radio, there apparently is agreement that the FCC should proceed forward with the project known as the Texas Instrument receiver. This is supposedly designed to reduce the number of channels needed for UHF channel television, so that present UHF TV channels could be allocated to other services.

We do not here today take a position on the merits of the receiver. We feel however that it would be inappropriate for the legislation that you have proposed—which would include this Texas Instruments receiver authority in its terms—to be adopted by the Senate or the House, because it would suggest in fact that the Texas Instruments receiver can work, and can do what it has been proposed to do, and what some people have represented it to do.

In fact, there are numerous problems with this receiver which need to be analyzed fully and carefully before any decision on its use is made.

In particular, we don't know what impact it would have on other services outside television. We also don't know the full impact it would have on television reception—both UHF and VHF.

Let me give you a particular example. As you may know, inside every television receiver there is an oscillator which drives some of the receiver components, and which acts like a miniature radio transmitter. Now this little transmitter can cause radio interference and this imposes some restrictions on the assignments of television stations. And the Texas Instruments' project is supposed to get rid of this. In fact, the TI receiver reduces the interference; but it also changes the frequency of the local oscillator so that a television receiver tuned to a VHF channel 11 might interfere with UHF channel 26. Or a Texas Instruments receiver tuned to channel 26 might interfere with someone in the land mobile bands.

I would suggest that the land mobile people—who are very interested in this project because they hope to obtain more spectrum—would be interested in looking at this particular problem, as well.

In addition, there are only three Texas Instruments prototypes available today. We don't know how they would hold up under consumer use and abuse. We don't know if the design can be manufactured in mass production and we don't know whether in fact it would work to increase channel loading at all.

All of these issues require careful study before any decision is made. Pertinently, the UHF task force at the FCC proposed that the FCC move forward on a land mobile development that might reduce the spectrum needed for land mobile by a factor of 10. The chief engineer of the FCC, and the then chief of the Safety and Specialty Bureau said that we can't go forward with this now; we need to study it very carefully before any decisions are made. MST believes that the same philosophy ought to apply to the Texas Instruments receiver. Again, we are not taking a position on its use today because there are too many unanswered questions.

The Texas Instruments receiver is an issue that is in the background of this proceeding. It is involved in the legislation, and we feel that for the Senate to act on this legislation now would be an indication to some—and perhaps to the FCC—that the FCC should proceed forward on this Texas Instruments project, when the full results aren't in.

As to the citizens band problem, we share Mr. Day's view that it is and that the FCC currently has authority to deal with a great majority of the problems of citizens band radio interference to television, as is shown in my statement.

Senator GOLDWATER. Thank you very much.
[The statement follows:]

STATEMENT OF PAUL J. BERMAN, COVINGTON & BURLING, REPRESENTING THE
ASSOCIATION OF MAXIMUM SERVICE TELECASTERS, INC.

All electronic devices are potentially susceptible to interference from radio frequency signals. Some kinds of interference, such as amateur radio interference to television reception, have been known for years and have been successfully solved on an ad hoc basis with the cooperation of all the parties involved. In contrast, Citizens Radio interference to television reception is both serious and widespread—it is expected to affect 9 million people in 1979. The proposed legislation proposes to deal with some of these problems by authorizing the FCC to set standards governing the operating characteristics of the home electronic equipment that receives the interference.

The Association of Maximum Service Telecasters, Inc., is intensely concerned about this problem. An organization of 200 television stations—commercial and non-commercial, serving cities, towns and rural areas—it is dedicated to maintaining and improving the high technical quality television service to which the American people are entitled and have become accustomed. Comprised only of television broadcasters, AMST has actively participated in recent FCC proceedings concerning CB interference to television free of the biases of either CB operators or of CB transceiver or television set manufacturers.

There are basically two mechanisms by which CB operations cause interference to television. First, CB transmitters, like all radio transmitters, generate signals called harmonics that fall at specific frequencies above the fundamental frequency on which the transmitter is being operated. What is important to know is that CB harmonics fall on frequencies which television receivers are supposed to pick up. This is the major source and cause of CB interference to television. If these CB harmonics are not adequately suppressed at the CB transmitter, interference to television results, no matter what the receiver standards set by the FCC.

A number of years ago, the FCC instituted a proceeding (Docket No. 20120) to determine what should be the level of harmonic suppression for CB transmitters. The massive volume of television interference complaints had proven that the 49 decibels of suppression previously required was wholly inadequate. AMST demonstrated that to avoid TV interference, CB harmonic suppression would have to be more than 100 decibels. The validity of this position has been borne out by a recent FCC report, but the Commission adopted a level of only 60 decibels in Docket No. 20120 and instituted another proceeding (Docket No. 21000) to review the question again.

CB interference to television is also caused, but to a lesser extent, when a strong CB signal on the fundamental frequency causes the television receiver to "overload." This can happen either because the CB signal is too strong or because the receiver does not filter out the unwanted CB signal properly. While the FCC's 1977 study of CB interference to television attributes 45 percent of the interference cases to receiver overload, the study does not assess whether the actual cause is too strong a CB signal or inadequate receiver filtering. However, a review of the study's raw data shows that in most cases of receiver overload, the CB transmitter was operated with an illegal linear amplifier, which was used to boost the power of the CB transmitter severalfold. In other words, the main source of the interference is also the CB transmitter, and its control is clearly within the FCC's present authority. The Commission's recent ban on the sale of these linear amplifiers, while long overdue, should in time be effective to ameliorate TV receiver overload problems.

In sum, the proposed legislation is neither necessary nor desirable. Nearly ninety percent of the complaints about home electronic devices received last year by the FCC concerned CB interference to television reception. On the one hand, regulation of TV receiver standards could not eliminate CB harmonic interference at all, which accounts for most interference. On the other hand, virtually all CB interference to TV could be eliminated through appropriate FCC action in the proper exercise of its current authority to regulate CB transmitters. Moreover, granting the FCC the additional authority to regulate receivers would indicate Congress' willingness to permit the Commission to avoid dealing with the problem by regulating CB transmitters which it already has authority to do.

The need is not for new legislation but for this Subcommittee's oversight to assure that the Commission carries out its present statutory mandate.

Senator GOLDWATER. I apologize for having to leave, because I did want to hear Mr. Jarrett and Mr. Foster.

Mr. Jarrett, I've read your paper, and I can offer an interesting experience of mine. I live in an apartment house, and a man three floors above me stuck a pin through my coax cable, effectively ruining it. I went up looking for what was wrong, and found the pin, and said, "What did you do that for?"

And he said, "Well, you were interfering with my television."

And I said, "I haven't been running the set in about 2 months." So they bought me a new cable.

I thank you all for coming.

Mr. STRASSBURGER. I don't think we've heard from Mr. Foster yet.

STATEMENT OF EDWARD J. FOSTER, CONSULTING EDITOR, HIGH FIDELITY MAGAZINE, GREAT BARRINGTON, MASS.

Mr. FOSTER. I have sent you our prepared statement.

Evidently, from the questions that have been raised, it has been received. There was some question as to whether anybody could ever figure out what postage was required.

I had also prepared a brief formal statement for this morning, but perhaps that's best left out, as well.

I am here as consulting editor for *High Fidelity* magazine to represent the consumer's—the high fidelity consumer's viewpoint—or what we consider that consumer's viewpoint to be. And as such, we are opposed to S. 864 as it is presently worded.

We do not believe it will adequately serve the needs of these consumers, and that it will require from them a substantial sacrifice not only in terms of monetary cost but also by way of a reduction of sound quality every time that the high fidelity system is turned on.

This cost is going to be imposed upon every audiophile, not just upon that segment of the population plagued by radio frequency interference if this bill is passed in its present form.

I think one point that has not been brought up with sufficient clarity this morning is the distinction between the "high fidelity system" and what I would title "consumer receiving equipment"—television sets, and perhaps FM sets. I had an inexpensive portable FM-AM radio that was totally wiped out any time an airplane landed at the nearest airport. My hi-fi set is not bothered in the least.

Television sets are especially susceptible to interference from CB transmitters because of the frequency allocation that the FCC has given the CB band. The harmonics of that band lie within the VHF

TV band, particularly on channels 2, 5, and 9. By the FCC's own study, harmonic suppression in many CB transmitters is inadequate.

Low-pass filters, added to television sets, will not eliminate the problem of inadequate harmonic suppression at the transmitter. Such filters may very well help to prevent overload of the television set and therefore prevent that sort of citizens band interference, but these filters are not a panacea. Where they may help a television set, they are unlikely, in our opinion, to be of much help to a high fidelity system. In fact, they may very well make matters worse.

I went through some technical reasoning to substantiate this point in the paper, and I don't think it is appropriate to go through all of that now.

But basically, I question even Mr. Feldman's seven protection points—whether that would do the job in all situations. And I would like to pick up on another point that has been made: A high fidelity set has to be looked at as a system, but the high fidelity industry is made up of component manufacturers.

You don't buy a complete system from one manufacturer. It is virtually impossible for a manufacturer of any particular piece of equipment to predict how that piece of equipment is going to be interconnected in the home. And so he simply cannot, in my opinion, rule out the possibility with any filters you can imagine—of possible interference from RFI.

And yet, S. 864 would authorize the FCC to make rules regarding the use of protective components in, I assume, all consumer electronic equipment. There is no distinction being made between the types of electronic equipment in which these components may be helpful, and the types for which they may not be helpful.

Mr. STRASSBURGER. May I ask a question?

Mr. FOSTER. Certainly.

Mr. STRASSBURGER. Would the addition of a filter necessarily result in deterioration of the sound?

Mr. FOSTER. It will depend upon, I think, the particular set, the particular filter and where it is introduced. As Mr. Feldman pointed out, as far as a phono input—a phono cartridge input—which is probably one of the primary sources of high fidelity listening—I think it is close to impossible to put in a filter without affecting the sound quality, given the present-day state of the art in phono cartridge design. And I question whether a filter will really eliminate RFI.

I will give you a case in point: Of all—and I mention this in the paper—of the hundreds of pieces of equipment that I have tested, I have found one particular piece of equipment that was susceptible—I think to a greater extent than normal—to RFI. That particular piece of equipment was designed with no RFI suppression techniques whatsoever.

The designer of that piece of equipment, realizing the situation, had provisions on the circuit boards for the inclusion of RFI-protection components, if and when they were needed. That a particular engineer has since designed other equipment. He has, I say, done an excellent job in eliminating RFI, and without the use of any filters whatsoever. And he has, in effect, produced a better piece of equipment by avoiding the use of filters.

Mr. STRASSBURGER. But who pays for the filters when they are needed on that equipment?

Mr. FOSTER. I can't answer you in this particular case. I'm not sure what the manufacturers' policy is with respect to paying for them. They may make a charge for them. They are an extremely reputable company, and they may just take care of a problem as it arises without charge. I really can't speak to that.

Mr. STRASSBURGER. Would it be accurate to say that even if they don't charge directly, the cost is probably passed along to the other customers.

Mr. FOSTER. I can't really state whether that is accurate. I rather doubt it. It is a small percentage of the high fidelity market that experiences RFI. I think it is a large percentage of the television market. And my personal opinion is that, whereas filters may very well be appropriate on television sets, they are not appropriate on high fidelity equipment.

Mr. STRASSBURGER. Has your magazine ever conducted a survey to find out how many high fidelity consumers are affected adversely by interference?

Mr. FOSTER. Not a formal survey.

Over the past several months there has been a good bit of editorial coverage of congressional action on these two bills, and that in itself generates letters from readers. And yet, when we counted these up, less than 5 percent of the letters had anything to do with RFI—even after the period of editorial coverage.

So in the sense that that is a survey, yes; but a formal survey, no.

Mr. STRASSBURGER. Thank you very much.

[The statement follows:]

STATEMENT OF EDWARD J. FOSTER, CONSULTING EDITOR, HIGH FIDELITY MAGAZINE

ABSTRACT

This paper considers the impact on the audiophile consumer of Senate Bill S. 864 to amend Section 302 of the Communications Act of 1934. Questions are raised regarding the practicality of RFI-immunity legislation affecting all consumer electronic equipment, the value that such legislation may have to the high-fidelity consumer, and the costs—both economic and technical—to that consumer.

The conclusion is reached that it is not in the consumer's best interest to empower the FCC to require the inclusion of "protective components," or to mandate in other ways, the degree of RFI immunity of consumer products other than those designed specifically for the reception of radio-frequency signals. Furthermore, while the benefit to the consumer offered by the present version of S. 864 is highly questionable, the economic and technical costs (as regards, for example, deterioration of the sound quality of a high-fidelity system) are substantial.

It is suggested that the amendment to Section 302 of the Communications Act of 1934 contained in Senate Bill S. 864 be restricted to include only consumer electronic equipment designed for the reception of radio-frequency signals. A suggested rewording of the bill is given in Appendix 2.

Speaking for the high-fidelity consumer, it is our opinion that any revision of the Communications Act of 1934 should insure that the freedom and imaginative design that has stimulated the high-fidelity industry is not frustrated. Specific government-mandated technical solutions, e.g. the specification of protective components, should be avoided. The vast majority of audiophiles, who do not experience RFI problems, should continue to be able to enjoy the highest quality in sound reproduction without the sonic degradation that such addition components may introduce. Nor should these consumers be forced to bear the cost of componentry that does not serve them.

SCOPE OF THE PROBLEM

To the audiophile suffering from radio-frequency interference, RFI is a major problem. After having made a considerable investment in his music system, he is plagued by sporadic reception of CB transmission or relatively continuous interference from a local commercial station. To the audiophile not suffering from such interference, RFI simply doesn't exist.

What percentage of audiophiles do experience RFI? While the exact percentage is unknown, after extensive editorial coverage that, in itself, tends to elicit letters from readers, less than 5 percent of High Fidelity's mail is concerned with RFI problems.

Of the High Fidelity staff, one editor reports occasional RF interference from CB transmitters in trucks passing within 100 feet of his equipment. Since this problem occurs rarely, he is convinced that these CB transmitters are using linear amplifiers to transmit at substantially higher power than is legally permitted. Another editor reports RF interference from his own (legal) CB unit, but only when it is very close (within 20 feet) to his audio equipment.

The author, having tested and reviewed hundreds of high-fidelity components in the past several years, has only experienced an RFI problem once. It is interesting to note that the particular piece of equipment involved was designed to achieve the highest quality phonograph-record reproduction, and RF-suppression filters were specifically avoided in the design because of the ill effects they impart to the accuracy of that reproduction. The manufacturer of this equipment was aware of the potential RFI problem and had field-installable modifications available to lessen RFI in those cases where such protection was needed. His philosophy was to provide the highest quality audio reproduction that is possible and to provide a "fix" for those situations requiring it. Such a philosophy can hardly be disputed from the consumer's standpoint.

From the letters received and from personal experience, we suspect that less than 1 percent to 2 percent of audiophiles have experienced RFI. And of these, many cases are due to improper operation of the high-fidelity system and are not "proper" instances of RFI. For example, the author was recently asked to aid in solving an "RFI problem" in a friend's equipment. The problem was traced to corroded contacts in the phono-cartridge headshell—contacts that had not been cleaned in 5 years. Such cases of "RFI"—and there are probably many of them—cannot be eliminated by legislation.

Apparently, the vast majority RFI is caused by CB transmitters, and it is most likely that the majority of that is traceable to the illegal use of CB linear amplifiers.¹ Evidently, the FCC does not find it feasible to locate these illegal transmitters and to take appropriate measures. The legislation presently being proposed strikes us as an immunization program funded by and imposed upon the healthy consumer to ward off a plague engendered by the failure of the government to enforce previous legislation.

COST TO THE CONSUMER

Such an immunization program costs the consumer in two ways. There is the obvious cost of adding extra components to the home equipment. But, to the high-fidelity enthusiast, there is another and more serious cost, that of a degradation in sound quality—the *raison d'être* of high fidelity.²

As discussed more fully in the next section, the average high-fidelity FM tuner is quite immune to RFI. This remarkable degree of immunity is due to the imaginative, sophisticated design and componentry that has been developed to serve this market segment. The high-fidelity enthusiast can easily pay much more for his audio system than for his television or, for that matter, for any other form

¹ In a recent study prepared by the Program Development and Evaluation Staff, Field Operations Bureau of the FCC (FCC/FOB/PD&E 77-02), linear amplifiers were associated with approximately 45 percent of all CB-TV interference cases. Since, unlike high-fidelity equipment, TV receivers are also subject to interference from the harmonics of CB transmitters (whether or not a linear amplifier is used), it is likely that a much greater percentage of CB-High-Fidelity interference is caused by the use of CB linear amplifiers. In our opinion, such illegal CB operation probably is the cause of the vast majority of CB-High-Fidelity complaints.

² It should be noted that this paper defends the interests of the high-fidelity consumer. It does not purport to represent the interests of the mass radio/TV market. It is very likely that television receivers and inexpensive portable and table model radios are highly susceptible to RFI, and that the inclusion of an RFI-suppression filter would result in improved reception.

of home entertainment. For this investment, he expects quality, and, by and large, he gets it.

Before buying a component, the audiophile is likely to spend considerable time studying specification sheets and critical reviews by magazines. Then he is likely to audition the equipment himself. He will probably be more knowledgeable about his high-fidelity system, and have selected it with more care, than he has shown in making such other major purchases as an automobile. In our opinion, the high-fidelity industry, serving an extremely knowledgeable consumer, must and does do an excellent job of policing itself vis a vis self-imposed technical standards. It is a highly competitive market in which technical excellence is the key to survival.

When RFI problems exist in a high-fidelity system, they are usually traceable to the introduction of radio-frequency energy into the input or output circuitry of the amplifier. It would seem rather straightforward to interpose a simple filter that would reduce the amount of RF energy to a negligible level. However, such a filter can have a significant—and, to the high-fidelity consumer, serious—effect on sound quality. This is discussed in greater detail in the following section.

By mandating, directly or indirectly, the inclusion of such filters, or any device that might limit the sonic level of excellence of which a component is capable, is not in the best interests of the high-fidelity consumer. In our opinion any high-fidelity component that is grossly susceptible to RFI will have that fact soon come to light and be forced off the market by consumer reaction. Such are the competitive forces in this industry.

THE DISTINCTION BETWEEN HIGH-FIDELITY COMPONENTRY, TELEVISION RECEIVERS, AND LOW-COST FM RECEIVERS

To various degrees, most electronic equipment is susceptible to radio-frequency interference. It is useful to classify the equipment into two groups: those devices designed to receive radio-frequency transmissions, and those whose purpose is other than radio-frequency reception. In the former category are such consumer products as AM and FM tuners and television receivers. Usually, the type of RFI problem experienced by these devices is the result of inadequate selectivity, image rejection and/or "front-end overload." In essence, the device is acting as it was designed to act, i.e. as a "receiver", but is susceptible to RF reception of signal frequencies to which it is not tuned. With such equipment, it is feasible to interpose traps, filters and the like, between the antenna and the receiver, to reduce the level of the interfering signal to that with which the receiver can cope. Television receivers are especially prone to CB-induced RFI since the harmonics of the CB band lie within several of the VHF TV channels.

High-fidelity AM/FM tuners are, for the most part, quite insensitive to this form of RFI. Methods of measurement of selectivity, spurious, image and IF response as well as of RF intermodulation (front-end overload) are specified by IEEE/IAF Standards (IAF-T-200, 1975/IEEE Std 185-1975). Marketplaces forces have resulted in a "specification race" with each manufacturer vying with the competition for the best circuit design for the price. The results have been gratifying from the consumer's viewpoint with better specifications available for less money in today's products than in those of 5 to 10 years ago.

Indeed, all high-fidelity tuners do not exhibit the same degree of RFI immunity. With some exceptions, the more expensive tuners exhibit better selectivity than do cheaper models. This is to be expected. Those of the more expensive tuners that do not match their competition as regards RFI immunity usually do so because of a conscious decision on the part of the designer to optimize the performance of the tuner as regards audio reception. Frequency response, distortion, and stereo separation are frequently compromised by a very high-selectivity design.

In our opinion, it would be very surprising to find a current high-fidelity tuner that is unable to meet a reasonable, legally-mandated, minimum level of RFI immunity. Any practical legal limit would have to be so low to accommodate portable and table model radios that current high-fidelity tuners would already exceed the requirement by a wide margin. Requiring the inclusion of additional filters would needlessly increase cost and compromise performance and not be in the consumer's best interest.

The second, and much more problematic group of electronic components, are those designed for purposes other than RF reception, which, nonetheless, may experience RFI. In the high-fidelity field, these components are amplifiers, pre-

amplifiers, tape recorders and microphones. Almost invariably, RFI susceptibility in these components can be traced to the introduction of RF energy either into the low-level audio stages, i.e. the phono or microphone preamplifier, or into the output circuitry via the speaker-connecting cables. Such RF pickup may be detected by the audio circuitry (due to nonlinear operation of the circuitry at these frequencies) and appear as noise or actual program material.

Note that the severity of the RFI is due as much (or more) to the amount of radio-frequency energy picked up by the cabling as it is to the properties of the amplifier or electronic device itself. The high-fidelity ensemble must be viewed as a system with the external cabling acting as an antenna, and the amplifier (or other device) as the "receiver." The length, type and routing of the interconnecting cables play a crucial role in establishing the RFI immunity of a given system. It would appear impractical to legally control such user-determined factors.

It has been stated that RFI could be eliminated by including filters and/or traps at the input (and output) terminals of the amplifier to block the admittance of the RF energy into the amplifier. In our opinion, this is easier said than done. (See Appendix 1.)

It has been well established that the load impedance presented by an amplifier to a phono cartridge is one of the most critical factors in determining the quality of reproduction. The interposition of an RF filter between the two can upset this delicate relationship. Some very imaginative engineering has gone into the design of this critical interface, all of which may be brought to naught by the interposition of a filter. In our opinion, it is not in the consumer's interest to mandate the inclusion of protective components (which may or may not solve an RFI problem that may or may not exist) when such components jeopardize the performance of the system for which the consumer has spent a great deal of money.

THE DIFFICULTY FORMULATING SUITABLE RFI LEGISLATION FOR HIGH-FIDELITY COMPONENTS

Since the proposed legislation is aimed at empowering a regulatory commission to pass rules regarding the elimination of RFI at the receiving device as well as at the source, it seems wise to postulate the possible ways in which those rules could be written and enforced. In our opinion, it would be extremely difficult—perhaps impossible—to formulate universal rules that would apply to all consumer electronic equipment and would be simultaneously practical, useful, enforceable and of reasonable ultimate cost to the consumer.

One conceivable rule formulation would require the manufacturer to insert a specific filter (presumably described by the rule) at each input and output terminal. While this would appear to be relatively inexpensive to do, it is unlikely to be effective in a high-fidelity system, and, in our opinion, would not be in the best interest of the consumer. The technical reasons for this statement are given in Appendix 1.

Whether the technical details of RFI-prevention filters are specified by ruling or are left to the discretion of the manufacturer, the statements made in Appendix 1 apply. In capsule form, we question the practicality of designing such filters when the high-fidelity equipment manufacturer has no control over the other components and the interconnections used within the home system. While such filters can be designed to work well under controlled test-bench conditions (and can be quite effective when used with a television receiver), it is highly unlikely that they will prove truly effective in the home high-fidelity system. In fact, they can make RFI susceptibility worse and, for the majority of consumers who do not have RFI problems, lead to a lower level of sonic reproduction. In our view, mandating the inclusion of such filters would be of negligible practical benefit to the consumer, would increase product cost and undermine the very property for which the product is being purchased.

Another conceivable formulation of a ruling would require a component to be immune to RFI under a certain specified RF field strength level. Presumably this would again be accomplished by the inclusion of filters and the comments of Appendix 1 apply. Furthermore, such a formulation would seem to imply some sort of Type Certification. This would further increase the cost to the consumer, bog down whatever agency is responsible for certification, and, inasmuch as certification would be accomplished under artificial test-bench conditions, would not assure RFI immunity in the home.

CONCLUSIONS

In our opinion, blanket immunity to RFI under all circumstances is an unrealistic goal. While inexpensive radios and television sets may suffer from RFI of a preventable type, high-fidelity tuners are relatively immune to such interference. While high-fidelity amplifiers (including the amplifier section of a receiver) may be susceptible to RFI under certain circumstances, in our opinion, these circumstances can usually be traced to an illegal CB transmitter, or, on occasion, to close proximity to a powerful legally-licensed transmitter. In the latter case, the interference level is so severe as to make it unreasonable to require that every component be able to withstand such interference.

As regards illegal citizens' band transmitters, we suggest that the problem and the cure lies in improved enforcement of present FCC regulations. We find it intellectually repulsive to require that the high-fidelity consumer pay an increased price to avoid interference from an illegal transmitter. This price is exacted in terms of increased cost for his equipment and in terms of poorer audio performance. At a time when more than one ostensibly consumer-oriented law has resulted in increased cost to the consumer without commensurate benefit, we urge that this legislation be modified.

APPENDIX 1

For an RF filter to be fully effective, it would have to be of the low-pass type, permitting low-frequency (audio) signals to pass and blocking high-frequency RF signals. Such filters function properly only if the input and output impedances are known and are uniform throughout the audio and RF spectra.

Consider the design of a filter to be used on a phono input. The input impedance is determined by the phono cartridge connected to the amplifier, and, at high frequencies, by the type and length of cable used to connect the cartridge with the amplifier. These factors are ultimately determined by the consumer and can vary widely. The amplifier manufacturer has no control over what is connected to his device and so cannot design a filter that is universally effective.

The termination impedance of the filter is under the manufacturer's control, but it is impractical to design a circuit with a constant impedance over audio and RF frequencies except by terminating the filter with a low-value resistor (typically 50 to 300 ohms). This is totally incompatible with a high-fidelity phono cartridge which requires a load of 47,000 ohms. The latter is an impedance level much too great for effective RF-filter design.

It has been established that the load presented by the amplifier to the phono cartridge is one of the most critical factors that determine the sound quality. The interposition of any filter jeopardizes the correctness of this interface and therefore potentially reduces the quality of performance. For this reason, it is not in the consumer's best interest to interpose such a filter.

The impedance of high-level inputs (e.g. Aux. Tuner, etc.) is typically greater than 25,000 ohms in order to avoid loading the source (e.g. tape deck, tuner, etc.). Again, this impedance level is too great for effective RF-filter design, and, again, the source impedance is determined by the components chosen by the consumer and so is not under the control of the amplifier manufacturer.

The design of a filter to be used at the output terminals to prevent feedback of RF energy that is picked up by the speaker cables also compromises performance. In this case, the speaker (and its cabling) present the source impedance, and the output impedance of the amplifier constitutes the filter termination. While the impedance levels are much lower than that typical of input circuits—and so would make the design seem more practical—the matter does not end there.

The speaker impedance is not constant and is not under the control of the amplifier manufacturer. A resistive pad could be used to control the impedance but at a great loss in power and at the expense of undamped speaker motion (with attendant poor sound quality. And while the output impedance of the amplifier is under the control of its manufacturer, it is hardly constant with frequency—nor is it feasible to make it such without exorbitant increase in cost.

From the above, we conclude that, at best, such filter would be marginally effective, and, at worst, could conceivably exacerbate the RFI problem if the terminations are incorrect. They also could result in a reduction in sound quality that audiophiles would find objectionable.

APPENDIX 2—A PROPOSED RESTATEMENT OF S. 864

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) section 302 of the Communications Act of 1934 (82 Stat. 290 47 U.S.C. 302a) is amended as follows:

(1) Subsection (a) of such section is amended—

(A) by inserting "(1)" immediately after "governing" in the first sentence;

(B) by striking out the period at the end of the first sentence and inserting in lieu thereof", and (2) governing the interference susceptibility of consumer electronic equipment designed for the reception of radio-frequency signals."; and

(C) by striking out "shipment, or use of such devices" in the second sentence and inserting in lieu thereof "or shipment of such devices and consumer electronic equipment designed for the reception of radio-frequency signals."

(2) Subsection (b) of such section is amended by striking out "'ship' or use devices" and inserting in lieu thereof "or ship devices and consumer electronic equipment designed for the reception of radio-frequency signals or use devices".

(3) Subsection (c) of such section is amended—

(A) by inserting "or consumer electronic equipment designed for the reception of radio-frequency signals" immediately after "devices" the first two times such term appears in the first sentence;

(B) by inserting "and consumer electronic equipment designed for the reception of radio-frequency signals" immediately after "Devices" in the second sentence; and

(C) by striking out "the common objective of reducing interference to radio reception," in the second sentence and inserting in lieu thereof "the objectives of reducing interference to radio reception and to consumer electronic equipment,".

(b) The heading of section 302 of such Act is amended to read as follows:

"INTERFERENCE WITH RADIO COMMUNICATIONS AND CONSUMER ELECTRONIC EQUIPMENT".

Mr. STRASSBURGER. Mr. Jarrett, did you want to enter your statement?

Mr. JARRETT. Yes, I would. I would like to read this statement.

STATEMENT OF JOHN S. JARRETT

Mr. JARRETT. I am Steve Jarrett, an amateur radio operator with an intense interest in S. 864. During the 23 years that I have been licensed by the FCC to operate an amateur station, I can recall numerous instances when it was alleged that my operations caused interference to radios, television sets, and high fidelity equipment. Thus, I am here today to review two recent cases of alleged radio frequency interference, RFI, which typify the plight of the amateur radio operator and the owner of electronic home-entertainment equipment, and to demonstrate why the subcommittee should approve S. 864 for subsequent consideration by the Senate.

In 1973 a neighbor complained of hearing my voice coming through his stereo system. An investigation and subsequent testing indicated that his Fisher stereo receiver was, in fact, causing the problem through a phenomenon known as audio rectification. More specifically, the audio output amplifiers in his stereo receiver were intercepting my signals, signals they should have been designed to reject. Since there is nothing a radio operator can do to prevent an audio device from behaving as a radio, two courses of action were possible: One, the consumer could take it upon himself/herself to install the necessary filtering components, or, two, a request can be made for the manufac-

turer to fix the problem. My neighbor, not being technically trained, chose the latter approach.

To assist in resolving the problem, I wrote to Fisher on my neighbor's behalf. I explained the situation and the results of the investigation, using technical terms where appropriate. There was no response from Fisher.

My neighbor then wrote to Fisher. He, too, received no response.

At this point, I appealed to the Electronics Industries Association, EIA, for their assistance. During a telephone conversation with the EIA director of consumer affairs for the consumer electronics group I was told that manufacturers should not be expected to protect their equipment from radio frequency energy because the problem disappears when the amateur station stops transmitting.

Neither my neighbor nor I was willing to accept this answer, and so we continued to press the EIA for help. Finally, nearly 10 months after the first letter to Fisher, this manufacturer, apparently acting under pressure from EIA, requested that the stereo receiver be returned to them for examination.

When the receiver was returned to my neighbor, there was no evidence that Fisher had done anything to correct the problem. Indeed, the device continued to intercept and rectify my signals, and at this point the neighbor simply gave up and resigned himself to live with the situation.

The second case also involves a neighbor, and was brought to my attention only a few months ago. This case involves a Panasonic clock-radio, two Sony color television sets, a Sansui stereo high fidelity receiver, and two stereo tape decks, Sansui and Teac. Though this equipment was otherwise well designed, it was highly susceptible to radio frequency energy. As a result of extensive testing by a specialist in the communications/electronics field and me, the following was determined:

The Panasonic clock-radio was so susceptible that my voice could be heard even when the radio was turned off.

The sound and picture on each Sony television set was severely affected when I transmitted. It was determined that installation of a commercially manufactured high-pass filter at the antenna terminals on each set eliminated most of the problem.

The Sansui receiver, the Sansui tape deck, and the Teac tape deck were severely affected by the presence of radio frequency energy.

This neighbor, with my assistance, has written letters to Panasonic, Sony, and Sansui requesting that they assist in resolving the RFI problems noted above. Since only a few weeks have elapsed since these letters were mailed, it is too early to determine if any or all of the problems will be resolved.

My reason for relating these two experiences is to highlight the fact that it is the consumer who must bear the burden of resolving an interference problem. Further, each manufacturer has a different policy on RFI problems, and as such, there is no assurance that a manufacturer will even provide assistance. Thus, in many cases, the consumer is frustrated in his attempts to resolve the problem, and often gives up in disgust.

The amateur radio operator shares this frustration because very likely there is nothing he can do to his transmitter to remedy the

problem. Most operators are reluctant to correct a manufacturer's design deficiency in a neighbor's device since to modify a piece of commercially built equipment can void any warranty in effect, or can lead to poor relations with a neighbor when the modified device eventually fails to operate, for whatever reason. Thus to keep peace in the neighborhood, many amateurs, like myself, voluntarily minimize their operating time during prime time hours.

Voluntary case-by-case assistance, when provided by responsible manufacturers, is only a temporary solution to RFI problems. In the long term, the solution requires legislation such as that embodied in S. 864. Only with such enabling legislation can the Congress and the FCC insure that the nontechnical public is offered electronic home-entertainment equipment which is capable of operating properly in today's radio-frequency environment.

Mr. STRASSBURGER. I have one question.

Was the FCC involved in attempting to resolve the interference at all?

Mr. JARRETT. Not directly. I used some of their publications to help in identifying where the problems were, but they were not involved in the solution of the problems, no.

Mr. STRASSBURGER. You referred to the varied policies manufacturers have concerning providing assistance to consumers; does anyone know what the policies of the manufacturers are?

Could that information be supplied for the record?

Mr. DAY?

Mr. DAY. Well, there is a well-established practice of the leading television manufacturers that if there seems to be a situation where an additional filter might help, they will furnish it, either at no cost or at nominal cost to the person who is making the request. However, as I have pointed out, our observation is that only about 20 percent of cases are improved by that kind of procedure.

Some of the manufacturers in cases where they think something could be done to improve the problem, as far as the receiver is concerned, will assist with analyzing and diagnosing the problem and even working with the service technician to tell him what to do.

We put out from the EIA two quite elaborate instruction books for service technicians as to what to do in interference situations, and I would like to give those to you for the files of the subcommittee.

One is on television interference; one is on audio rectification.

These tell how to diagnose what is happening from the appearance of the television screen or from the type of noises or voices you are getting, and it tells what can be done in cases where something can be done.

In connection with the specific case Mr. Jarrett brought up, we would like to have permission to file a statement commenting on that, because if it is the same case that we recall, it was a piece of equipment that was 10 years old to begin with, and we have a different recollection of the EIA's role in that correspondence.

[The following information was subsequently received for the record:]

The first case noted in Mr. Jarrett's statement involved a Mr. P. M. Downs who resided at 8802 Camden Street, Alexandria, Virginia. The products involved included a phonograph, loudspeakers and a Fisher Radio Corporation amplifier purchased in 1968.

Mr. P. M. Downs wrote to the EIA/CEG Director of Consumer Affairs on November 16, 1973, complaining about interference from an amateur radio operator living next door. He was informed by letter dated November 26, 1973, that because three different manufacturers were involved, his case of interference was being presented by EIA/CEG to each of the companies involved.

Two of the companies responded to Mr. Downs, one by letter dated November 30, 1973, and the other by letter of December 11, 1973, suggesting possible ways to deal with the problem. A representative of Fisher Radio Corporation spoke to Mr. Downs by telephone.

Mr. Jarrett then joined in the correspondence about the same complaint. In early September 1974, Fisher sent to Mr. Downs a kit containing capacitors and directions for insertion. Apparently, Mr. Downs didn't wish to perform this work, so in a telephone conversation with the service manager at Fisher, he was advised to return the product involved to Fisher. Capacitors were inserted in the input and output jacks and wherever ground loops were found they were eliminated. At no time does Fisher's correspondence indicate that such action would totally eliminate the ham radio interference but only that perhaps such action might reduce it to a tolerable level.

In January of 1975, Mr. Jarrett filed a complaint of interference. This was forwarded by EIA/CEG to Fisher Radio which advised that because the product was then ten years old they would not authorize its return for modification.

The second case mentioned in Mr. Jarrett's statement concerns the same house, 8802 Camden Street, but a different resident. This man, too, says he is experiencing interference on two television sets, a receiver, a cassette tape player and a turntable. It is understood that one of the manufacturers has already contacted this resident requesting information so that their engineers can make possible suggestions. The television manufacturer has sent the gentleman two filters for his sets, and EIA/CEG will continue to work with the remaining manufacturers to try to assist in alleviating interference difficulties.

Mr. STRASSBURGER. Your statement is welcomed.

Mr. Dannals?

Mr. DANNALS. Yes.

In response to your question, ARRL, the ARRL, the American Radio Relay League, established a task group years ago and part of its task was to survey the television manufacturers and determine what action they would take in cases of interference requiring the possible installation of a filter.

We have such information tabulated, and members of our staff will make certain that a copy of this information is made a part of the record.

[The article follows:]

RFI Assistance List

Suppress your RFI difficulties and your frustration as well. Consumer service help is available from these manufacturers.

By Harold R. Richman,* W4CIZ

One of the significant accomplishments of the ARRL RFI Task Group has been this RFI Assistance List. Particular thanks must go to Hal Richman, W4CIZ, whose individual efforts and devotion to accuracy have been instrumental in making this list one of the most respected documents in the RFI literature. This is evidenced by the fact that the FCC includes this very list in its latest RFI publication: How to Identify and Resolve Radio-TV Interference Problems.

And a note of thanks should go to the manufacturers who have allowed their names to be included in this list. They are voluntarily offering their assistance to the public in an effort to help alleviate the growing RFI problem, and their cooperation is deeply appreciated.)

Admiral

RFI complaints are usually handled by the local Admiral dealer service technician. "National service personnel are available to assist the technician when needed. Admiral maintains its own staff of technical representatives who travel in the field and may be called upon to assist the dealer technician with difficult problems, including RFI. Admiral provides technicians with various instruction bulletins dealing with rf interference suppression." RFI complaints should be referred to the local Admiral dealer. If front-end overload or cross modulation occurs in areas of extremely high-level transmitter radiation, the National Service Division has suitable traps available at no charge to the customer. Write for such information to the National Service Division, P. O. Box 2845, Bloomington, IL

60701. Attention: Mr. R. E. Gremer.

Akai America

Akai products include audio tape recorders, video tape recorders, a-m/fm receivers, speaker systems and related accessory products. Inquiries related to RFI should be addressed to Customer Service Department, 2139 E. Del Amo Blvd., Compton, CA 90220. Tel. 213-537-3880. "Upon receipt of these inquiries, we will investigate the situation and, to our utmost, try to resolve the customer's problems."

Allen Organ Co.

When a complaint is received via the dealer, Allen Organ Company sends the dealer an informational service bulletin on RFI and sufficient components to cover all amplifiers in the affected instrument. This service is offered at no cost to the customer. Refer RFI problems to the local Allen dealer. Inquiries may be directed to Mr. David L. George, National Service Manager, Macungie, PA 16162. Tel. 215-965-9801.

Altec Lansing

Customer RFI problems are referred to the authorized Altec warranty stations located nationwide and denoted by an information card furnished with each piece of equipment. Unusual situations are, at the option of the warranty station, referred to Altec Customer Service, 1515 W. Katella Ave., Anaheim, CA 92803. Tel. 714-774-2900 or to the Engineering Department, 1515 S. Manchester Ave., Anaheim, CA 92803. Attention: Chief Engineer, Electronics.

Arvin Industries, Inc.

Customer problems involving RFI should be referred to Mr. John Currey,

Manager of Field Service, 15th St., Columbus, IN 47201. Tel. 812-372-7271.

Audio Research Corp.

In the event of an RFI problem, customer may write to Mr. Scott Crist, Chief Engineer, P. O. Box 6003, Minneapolis, MN 55406. Tel. 612-721-2961.

Baldwin Piano & Organ Co.

RFI complaints are usually handled by the local Baldwin service technician. Factory personnel are available to assist the technician when needed. Baldwin maintains its own staff of technical representatives who travel in the field and may be called upon to assist the dealer technician with difficult problems, including RFI. Baldwin provides technicians with a detailed instruction bulletin entitled "Hints on Suppressing RF Interference." RFI complaints should be referred to the local Baldwin dealer. Inquiries may be directed to Mr. Robert C. Scherer, Manager, Organ Technical Service, 1801 Gilbert Ave., Cincinnati, OH 45202. Tel. 513-621-4300.

Benjamin Electronic Sound Co.

Refer RFI problems to Mr. Robert Rosenberg, Service Manager, 790 Park Ave., Huntington, NY 11743. Tel. 516-673-8600.

Capehart Corp.

Capehart Corporation, manufacturer of stereo console phonographs and radios, asks that the customer refer an RFI problem in their product to Mr. Elliott S. Scheff, General Manager, Capehart Corporation, 5th St., Norwich, CT 06360. Tel. 203-886-0111.

Conn Organ Corp.

RFI complaints should be referred to

*ARRL RFI Task Group, 3908 Lake Blvd., Annandale, VA 22003

the local Conn dealer, whether instrument is in or out of warranty. Factory assistance is available to the dealer if he is unable to correct the RFI. RFI problems encountered within term of instrument warranty are usually corrected by the selling dealer without cost to the organ owner. Mr. Thomas A. Umbaugh, Assistant Service Manager, 1101 East Beardsley Ave., Elkhart, IN 46514. Tel. 219-264-7511.

Curtis Mathes

Curtis Mathes products include color TVs and stereos (100-percent solid-state) in portable, console and combination configurations. Customer complaints involving RFI should first be resolved at the retail-dealer level. If not satisfied, then the complaint should be made in writing to the Consumer Relations Department giving all details of the problem, along with the model info, serial number, date of sale, dealer and service history. Each complaint will be handled individually. Write to P. O. Box 151, Athens, TX 75751. Attention: Consumer Relations Department.

Dumont (See Emerson Quiet-Kool Co.)

Dynaco-Dynakitt Division of Tyco Laboratories

Inquiries related to RFI involving Dynaco products should be addressed to Customer Service Department, Dynaco Division Tyco Laboratories, Coles Road, P. O. Box 88, Blackwood, NJ 08012. Tel. 609-228-3200. Dynaco has available for owners of Dynakits an excellent information sheet on solving RFI problems.

Elpa Marketing Industries, Incorporated

Complaints are handled with respect to parts and labor on an individual basis. Necessary modifications for RFI are made on a no-charge basis, parts and labor, during the term of instrument warranty. Beyond warranty, modification parts are available free of charge. Customer then pays for labor involved in the installation of the parts. Refer RFI problems to Mr. John F. King, Thorens Building, New Hyde Park, NY 11040. Tel. 516-746-3002.

Emerson Quiet-Kool Company

Customers should refer RFI problems, or inquiries related to Emerson or Dumont TV problems, to Mr. Jerome Roth, P. O. Box 300, Woodbridge, NJ 07095. Tel. 201-381-7000.

Fisher Corporation

Fisher Corporation asks that RFI problems involving a Fisher product be handled as follows: (1) Request assistance from the local selling dealer; (2) Request assistance from the local Fisher authorized service station (a list is packed with every Fisher unit). Contact with local Fisher agencies is the preferred method of

handling. Fisher's service coordination group maintains close communication with Fisher authorized service stations, Fisher's Engineering Department, and works under the supervision of the office of the National Service Manager. If the problem cannot be solved at the first two service levels, contact Service Coordination, 21314 Lassen St., Chatsworth, CA 91311. Tel. 213-998-7322.

Garrard Plessey Consumer Products

Garrard advises the consumer on methods which may eliminate RFI. In unique cases where the suggestions are ineffectual, customer should refer the RFI problem to Mr. Havens or Mr. Coll. "Any RFI problems which are referred to us are always handled on a no-charge basis." Mr. Ed Havens or Mr. Ron Coll, Assistant Service Managers, 100 Commercial St., Plainview, NY 11803. Tel. 516-694-7377.

General Electric Co.

RFI problems involving G.E. television receivers should be referred to the nearest General Electric Customer Care Service Operation. If G.E. Customer Care Service is unable to correct the RFI, the customer should refer the problem to: Manager, Product Service, Television Business Department, College Blvd., Portsmouth, VA 23705. All RFI problems involving G.E. radios, record players, and other audio products should be referred to Manager, Customer Services, Electronics Park, Syracuse, NY 13201.

Gulbransen

Gulbransen cooperates with dealers and customers in offering suggested solutions to RFI. Gulbransen does not reimburse the consumer for servicing. However, when extreme cases are encountered due to proximity of the transmitter and relative power, the dealer may sometimes absorb the cost of servicing RFI problems. Customers should refer RFI problems to the local dealer. Inquiries may be directed to Mr. J. A. Iacono, Consumer Service Supervisor, 100 Wilmot Rd., Deerfield, IL 60015.

Hammond Organ Co.

Hammond maintains a staff of technical service representatives who become directly involved in RFI cases that the dealer's service personnel are unable to solve. Hammond states that the services of engineering and technical field service departments under its control are provided to consumer and dealer alike without charge, whether or not a product is within warranty. RFI problems should be referred to the local Hammond dealer. The Hammond Technical Service Department asks that it be informed of any unique interference problem involving the Hammond instrument. Mr. J. J. Welch, Technical Field Service Manager, 11700

Copenhagen Ct., Franklin Park, IL 60131. Attention: Technical Service Department.

Harman-Kardon, Inc.

Customers should refer RFI problems to Mr. Len Gaynor, Manager of Customer Service. Customer RFI problems are handled on an individual basis. If local, the customer is invited to bring the affected set into the plant. Nonlocal customers are referred to the nearest warranty station. Corrective action is provided at no cost to the customer. Subsidiary of Jervis Corporation, 55 Ames Ct., Plainview, NY 11803. Tel. 516-681-4000.

Heath Schlumberger

Heath Company suggests that, for fastest service on matters related to RFI, regardless of the product line involved, customers may now reach the Technical Consultation Department by either writing directly to that department, Heath Company, Benton Harbor, MI 49022, or by using a new direct-line telephone system to the department — 616-982-3302. Do not write to an individual.

Hitachi Sales Corp. of America

Customers with RFI problems should contact the service manager of the nearest regional office: Western Regional Office, 401 W. Artesia Blvd., Compton, CA 90220; Midwestern, 1400 Morse Ave., Elk Grove Village, IL 60007; Eastern, 48-50 34th St., Long Island City, NY 11101; Midwestern, World Trade Center 183, 2050 Stemmons Freeway, Dallas, TX 75207.

J. C. Penney

J. C. Penney Company asks that customers with RFI problems contact their nearest J. C. Penney store for personal assistance. 1301 Avenue of the Americas, New York, NY 10019.

JVC America, Inc.

Inquiries related to RFI involving JVC products may be referred to the office of Mr. Akira Deguchi, Chief Engineer, 50-35 56th Rd., Maspeth, NY 11378. Tel. 212-392-7100.

Kenwood Electronics, Inc.

Kenwood asks that customers with RFI problems take the affected unit to an authorized service center where an adjustment will be made at no cost to the customer if the product is properly registered with Kenwood and within warranty. It is suggested that prior authorization for the return be obtained from Mr. Toshi Furutsuki, 15777 South Broadway, Gardena, CA 90248. Tel. 213-323-1400.

KLH Research & Development Corp.

KLH initially provides the customer with a listing of suggested steps for

isolating and correcting RFI. If self-help does not resolve the problem, the customer may write to Jeff Ayres, Manager, Customer Service, 30 Cross St., Cambridge, MA 02139, for authorization to return the affected unit to the factory. Return can then be made through contact with the nearest KLH factory authorized service station. Customer bears the responsibility for shipping the unit to and from the repairing service station. KLH absorbs the cost of service for their units as long as the unit is covered by a KLH warranty and is returned to the factory.

Lafayette Radio Electronics Corp.

Customers should refer RFI problems involving Lafayette products to the local dealer. If the dealer cannot alleviate the problem, the customer may contact Mr. P. Morgillo, Vice President, Engineering, 111 Jericho Turnpike, Syosset, NY 11791. Tel. 516-921-7700.

Marantz (See Superscope)

Magnavox Consumer Electronics Co.

Customers should direct RFI problems involving Magnavox products to Magnavox at the nearest of the nine divisional service offices: Pacific Division, 1360 San Mateo Ave., South San Francisco, CA 94080; Los Angeles Division, 2645 Maricopa St., Torrance, CA 90503; Southwestern Division, 8813 John Carpenter Highway, Dallas, TX 75247; Great Plains Division, 7510 Frontage Rd., Skokie, IL 60076; Great Lakes Division, 24092 Detroit Rd., Westlake, OH 44145; Southeastern Division, 1898 Leland Dr., Marietta, GA 30062; Northeastern Division, 607 North Ave., Door 17, Wakefield, MA 01880; New York Division, 161 East Union Ave., East Rutherford, NJ 07073; Mid-Atlantic Division, 2201 Rte. 38, Suite 750, Cherry Hill, NJ 08034.

McIntosh Laboratory, Inc.

McIntosh has a number of authorized service agencies located throughout the country. Customers will be assisted to receive prompt help. RFI and other service related problems can be directed to Mr. Albert Hyle, Customer Service Manager, 2 Chambers St., Binghamton, NY 13903. Tel. 607-723-3512.

MGA Mitsubishi Electric Corp.

Melco Sales, Inc., is the sales and service representative for the Mitsubishi Electric Corporation. RFI reports from the field, beyond the dealer's capability to resolve, in which Melco Sales becomes involved, are handled on an individual basis. "All attempts will be made to give customer satisfaction." Melco Sales suggests that requests for assistance be addressed to 3030 East Victoria St., Compton, CA 90221, or the Service Department may be contacted by telephone on a toll-

free number — 800-421-1132. Mr. Chuck Trout is the National Service Manager.

Midland International Corp.

Midland asks that, should any RFI problems be encountered with their portable black-and-white and color TVs, individuals contact Mr. Gene Pipes, General Service Manager, P. O. Box 1903, Kansas City, MO 64141. Tel. 816-842-5922.

Montgomery Ward

Service for RFI should be obtained from the nearest Montgomery Ward location. If service is not obtainable locally, customer may write to the customer service product manager at the corporate headquarters in Chicago. Corporate Offices, 535 West Chicago Ave., P. O. Box 8339, Chicago, IL 60680. The Montgomery Ward field service organization can call upon factory and corporate engineering talent for assistance in handling difficult RFI problems.

Morse Electro Products Corp.

"RFI complaints related to Morse/Electrographic entertainment products may be referred to Customer Service Manager, 101-10 Foster Ave., Brooklyn, NY 11236. Tel. 212-257-7000."

Nikko Electric Corp. of America

Nikko's line of products includes stereo receivers, tuners, amplifiers, combination pre-amp and main-amp pairs. For information and assistance with any Nikko Electric products, inquiries should be made to Mr. Les Aubin, National Service Manager, Service Department, 16270 Raymer St., Van Nuys, CA 91406. Tel. 213-988-0105.

Norlin Music, Inc.

Norlin offers local service organizations technical help in treating RFI through the Norlin Service Manager and his staff assistants. Customers should refer RFI problems to the local Lowrey dealer. Inquiries may be directed to Norman B. Erickson, Director of Engineering, 7373 North Cicero Ave., Lincolnwood, IL 60466.

North American Phillips Corp.

Each RFI situation is handled individually by the service manager of the particular division whose product is involved. Inquiries related to RFI should be addressed to the proper division at 100 E. 42nd St., New York, NY 10017. Tel. 212-697-3600.

Nutone Division

Refer RFI problems to Mr. Norman W. Aims, W8JYD, Consumer Relations Department, Scovill Housing Products Group, Madison and Red Bank Roads,

Cincinnati, OH 45227. Tel. 513-527-5415.

Panasonic Co.

When instances of RFI occur, the customer should contact Panasonic at the following address: Panasonic Company, Div. of Matsushita Electric Corp. of America, 50 Meadowlands Parkway, Secaucus, NJ 07094. Attention: Mr. Warren Oppenheimer. Tel. 201-348-7000. Customer should provide model number, serial number, and information concerning the problem. Upon review of the problem, the customer will be contacted and advised where to return the unit for corrective repair. "Panasonic will absorb both parts and labor costs in these instances."

Philco-Ford (See GTE Sylvania)

Quasar Electronics Corp.

For a high-pass filter, consumer should contact Quasar Electronics Corporation, Consumer Relations Manager, 9401 West Grand Ave., Franklin Park, IL 60131. Model and serial number of the receiver, frequency of the interfering signal if known, should be included with the written request, as well as whether sound or picture, or both, are affected. The Quasar distributor serving the local area should be contacted relative to any other interference problem that is unique to Quasar products.

Radio Shack

Customers who encounter unique interference problems involving Radio Shack audio products may write to Mr. Frank Roberts, Product Development Manager, or Mr. Peter Falcone, National Quality Control Manager, National Headquarters, 2617 West Seventh St., Fort Worth, TX 76107. Tel. 817-335-3711.

RCA Consumer Electronics

RFI problems involving both television and audio products may be referred to Mr. H. L. Carter, 1-455, 600 N. Sherman Dr., Indianapolis, IN 46201. Tel. 317-635-9000, extension 4255. Requests for filters should include model number and serial number of the RCA television receiver. Filter installation charges will be the customer's responsibility.

Rodgers Organ Co.

RFI problems involving the Rodgers Organ may be referred to Mr. Dale T. Justice, Custom Organ Test Department, 1300 N. East 25th Ave., Hillsboro, OR 97223. Tel. 503-648-4181.

Rotel of America, Inc.

Stereo receivers, amplifiers, tuners and tape decks. RFI problems should be referred to Michael Gregory, National Service Manager, 1055 Saw Mill River Rd., Ardsley, NY 10502. "RFI problems will

be handled according to the terms of our limited warranty."

Sansui Electronics Corp.

RFI problems should be directed to Mr. Gerald M. LeBow, Vice President, 201 Communications Inc., 201 East 42nd St., New York, NY 10017. Tel. 212-867-3325. 201 Communications, Inc., is the advertising and public relations agency representing Sansui. Mr. LeBow will direct the customer to an appropriate Sansui Service Center. Mr. LeBow states that all Sansui products are carefully checked prior to final engineering commitments for susceptibility to RFI. "Units are often taken to high-rf-level areas such as New York City to determine any design flaws."

Sanyo Electric, Inc.

In the event an RFI problem should occur, the customer is requested to take the set to the nearest Sanyo authorized repair station. Transportation to and from the shop is the responsibility of the customer. Should the shop not alleviate the problem, either the customer or the shop should contact Mr. Thomas R. Smith, Field Service Manager, Sanyo Electric, Inc., Electronics Division, 1200 W. Artesia Blvd., Compton, CA 90220. Tel. 213-537-5830.

Schober Organ Corp.

Customers with RFI problems are supplied with the necessary parts, free of charge, to correct the trouble. Schober Organ Corp. also assists customer in location of offending stages in the organ. Refer RFI problems to Mr. Warren A. Boehling, Development Engineer, 43 West 61st St., New York, NY 10023. Tel. 212-586-7552.

Scientific Audio Electronics, Inc.

Refer RFI inquiries to Mr. Michael L. Joseph, National Marketing Manager, P. O. Box 60271, Terminal Annex, Los Angeles, CA 90060. Tel. 213-489-7600.

H. H. Scott, Inc.

Manufacturer offers simple instruction sheet to aid customers in resolving problems involving rf pickup. The information includes suggestions about suitable equipment grounding, power line bypassing, hints and suggestions on how to determine where rf is entering the equipment. Customers should refer any RFI problems to Mr. D. F. Merryman, Engineering Dept. 111 Powder Mill Rd., Maynard, MA 01754. Tel. 617-897-8801.

Sears, Roebuck & Co.

Sears asks that customers with an RFI problem involving a Sears product contact the nearest Sears service department for assistance. Inquiries may be directed to Mr. R. C. Good, Manager, Marketing

Communications, Home Appliances, Dept. 703, Sears Tower, Chicago, IL 60684.

Sharp Electronics Corp.

Sharp Electronics will, with proof of purchase, supply customers with a Drake TV-300 high-pass filter at no cost. Audio rectification problems are handled on an individual basis by the Service Department. Refer RFI to Service Manager, 10 Keystone Pl., P. O. Box 588, Paramus, NJ 07652. Tel. 201-265-5600.

Sherwood Electronic Laboratories, Inc.

Customers with interference problems should contact Mr. John Davis, Service Laboratory Manager, Sherwood Electronics Laboratories, Inc., 4300 N. California Ave., Chicago, IL 60618. Tel. 312-478-7300.

Shure Brothers, Inc.

Manufacturer recommends the use of balanced-line, low-impedance microphones, cables. . . If an RFI problem persists after the above measures have been taken, the customer should contact Shure Brothers, Inc. with specifics, so that they may be able to help solve the problem. Refer RFI problems to Mr. F. F. Hoffman, Customer Service Manager, 232 Hartrey Ave., Evanston, IL 60204. Tel. 312-679-5830.

Sony (Consumer audio tape products only — see Superscope)

Sony Corp. of America

RFI problems involving Sony products should be directed to Sony at 47-47 Van Dam St., Long Island City, NY 11101. Attention: Customer Care Department. Tel. 212-361-8600.

Soundesign/Tanglewood Audio Corp.

Soundesign/Tanglewood Audio Corp. requests that all service problems relating to *non-stereo merchandise* be referred to Mr. Noel H. Goldman, National Service Manager, 34 Exchange Pl., Jersey City, NJ 07302. Tel. 201-434-1050. "All service problems on stereo merchandise is to be referred to our authorized service centers. The nearest one can be found by calling toll-free in the continental U.S. 800-243-6000, and in Connecticut, 882-6500."

Superscope Corp.

Superscope/Marantz a-m/fm receivers, tuners, amplifiers, tape recorders, record players, and audio systems. Sony consumer audio tape products. In the event of special RFI cases resulting from extremely high fields, contact Technical Services Department at Superscope corporate offices. "Modifications necessary to resolve such RFI problems are provided to

customers on an individual basis." 20525 Nordhoff St., Chatsworth, CA 91311. Tel. 213-998-9333. Attention: Mr. A. M. Williams, Manager, Research and Engineering.

GTE Sylvania, Inc.

Sylvania policy: "Factory field service and field engineering personnel work together to solve many of the TVI and audio rectification problems. If the consumer has an interference condition, he should contact his local dealer. He is in touch with the manufacturer's services that will help resolve it." Consumer should contact the dealer and work through his services first. RFI problems are handled on an individual basis. Sylvania has available for its technicians an excellent pictorial TVI training manual titled, *Diagnosis, Identification and Elimination of TVI*. Entertainment Products Group, Group Headquarters, 700 Ellicott St., Batavia, NY 14020. Tel. 716-343-3470. Mr. Jack Berquist, Field Training Supervisor.

Tandberg of America, Inc.

When RFI occurs in Tandberg products the manufacturer suggests that the unit be returned to them. "We will do any modification possible to eliminate the RFI." Authorization should be obtained from Mr. Tor Sivertsen prior to return of the unit. Mr. Tor Sivertsen, Technical Manager, Labriola Ct., Armonk, NY 10504. Tel. 212-892-7010.

Tenna Corp.

Tenna Corporation has not produced home-entertainment equipment within the past two years, but will be glad to help out all past customers if a problem arises with RFI. They will install circuit change at no cost, except postage and handling. All unique RFI problems may be referred to Mr. Tom Beuck, National Service Manager, 19201 Cranwood Parkway, Cleveland, OH 44128. Tel. 216-475-1400.

Thomas Organ Co.

RFI is usually resolved at the dealer level. If the manufacturer's field service is made aware of a consumer complaint regarding RFI, they contact the seller and advise him on how to eliminate the problem. Should that fail, "we continue to pursue the problem utilizing our own people." Thomas Organ Company has six field service engineers. In the event of a call for assistance, an engineer personally contacts the consumer by telephone, makes an appointment to visit the home of the consumer to correct the RFI condition, with or without the dealer's technician. "We do not charge the consumer for this service." Refer RFI complaints to the dealer. Inquiries may be directed to Mr. Daniel E. Hofer, Manager, Field Service, 7310 North Lehigh Ave., Chicago, IL 60648. Tel. 312-647-0700.

Toshiba

Customers should contact the nearest regional office for obtaining assistance in resolving RFI problems involving Toshiba televisions, radios, tape products, amplifiers, tuners and receivers. Eastern Regional Office, Mr. Terry Hogan, Field Service Manager, 41-06 Delong Street, Flushing, NY 11355. Tel. 212-939-7400. Western Regional Office, Mr. S. Ito, Regional Service Manager, 19515 S. Vermont Ave., Torrance, CA 90502. Southwest Regional Office, Mr. Tom Underwood, Regional Service Manager, 3225 E. Carpenter Freeway, Irving, TX 75062.

U.S. Pioneer Electronics Corp.

Consumers in the Eastern region may contact Mr. Fred Ellis, 75 Oxford Dr., Moonachie, NJ 07074; in the Midwest, Mr. John Kempinski, 1500 Greenleaf Ave., Elk Grove Village, IL 60007; in the Western region, Mr. Steve Hase, 13300 South Estrella Ave., Gardena, CA 90248.

Wells-Gardner Electronics Corp.

"Wells-Gardner is a private-label manufacturer of consumer electronic

products. Inquiries related to RFI should be referred to our private label customers whose address appears on the model-number label attached to the product. Special problems which may be encountered by private label customers are usually referred to Wells-Gardner." 2701 N. Kildare Ave., Chicago, IL 60639.

The Wurlitzer Co.

"The Wurlitzer Company makes available a toll-free telephone line, 800-435-2930, to assist any technician or customer in any and all needs pertaining to the Wurlitzer product. The Wurlitzer Company maintains a staff of field service managers who can assist should an RFI problem arise." 1700 Pleasant St., DeKalb, IL 60015.

Yamaha International Corp.

Yamaha organization attempts to cure each RFI problem on an individual basis. Yamaha supplies all necessary technical information at no charge. If interference is due to design error, Yamaha takes steps at its own expense to remedy the problem. Refer RFI problems to the local dealer. The dealers are kept well informed and

current on RFI countermeasures. Inquiries may be directed to Mr. Dan Bryden, WA6PXO, Electronic Service Department, 6600 Orangethorpe Ave., Buena Park, CA 90622. Tel. 714-522-9011.

Zenith Radio Corp.

Zenith gives consideration to handling and providing relief for RFI problems on a case-by-case basis. RFI problems should be referred to Service Division, 11000 Seymour Ave., Franklin Park, IL 60131. Tel. 312-671-7550. RFI referrals should include model and serial number of the affected product. Customers with a unique, difficult RFI problem may direct a letter to Mr. Brian J. Marohnic, W9DCN, National Service Manager, same address.

Other Manufacturers

Ms. Sally Browne, Director of Consumer Affairs, Consumer Electronics Group, Electronic Industries Association (EIA), 2001 Eye Street, N.W., Washington, DC 20006. Tel. 202-659-2200, may be contacted for assistance in handling RFI problems involving manufacturers who are not listed here.

Mr. STRASSBURGER. Thank you very much.

Mr. Feldman?

Mr. FELDMAN. The manufacturers of the Institute of High Fidelity that I represent universally will attempt every corrective measure when the kind of situation that has just been described is brought to their attention.

However, there is one problem. Generally, one takes the piece of equipment, be it a receiver or an amplifier, back to the manufacturer's authorized service center or even his factory, if it is local. In that instance, of course, the technician cannot perceive the problem because we are no longer in the location where the problem exists. So very often you find 10 or 12 trips back and forth in an attempt to do it by trial and error, because we are not duplicating the problem as it exists.

In any event, however, I want to stress that our position is not really that this problem is one of amateur radio vis-a-vis high fidelity. It is primarily CB versus high fidelity. The amateur radio situation constitutes a tiny, tiny, fragment of a percentage of the problem.

Mr. FOSTER. I would concur with Mr. Feldman on that. I don't think that it is amateur radio that is the prime culprit here. And I would like to make reference again to the FCC study where they found that 46 percent of the cases of CB television interference were traceable to the use of illegal linear amplifiers. That 46 percent was based upon the number of people who admitted using an illegal linear amplifier. I have a feeling that it is probably substantially higher than 46 percent, if the truth were really known.

The FCC found that the average power of these linear amplifiers was 117 watts. Four is the legal input power limit, in accordance with FCC regulations. With the high-gain antennas used, the average effective radiated power was 700 watts. This is quite a bit greater than four. This is obviously an illegal use of the citizens band.

But what is being done to get the illegal CB equipment off the market and the illegal CB operator off the air? Why should every consumer have to pay to have protective circuits built into every piece of equipment so that these people can continue to operate illegally?

Mr. STRASSBURGER. But receiver design is part of the problem; isn't that correct?

Mr. FOSTER. I think receiver design would be found to be in large part satisfactory if the CB people were all legal—barring specific cases of an amateur radio operator running a kilowatt legally a few feet away from a television receiver. And in that case, I'm not sure just how much filtering, if any amount, is going to fix the situation.

Mr. STRASSBURGER. I think we have time for one more comment. Mr. Hannold?

Mr. HANNOLD. I did want to emphasize that there is a great difference of opinion here about the quality compromises entailed in by-passes and other filtering measures in audio devices.

We are talking about the last ounce of quality, and we, meaning the stereophile, we are opposed to anything which entails any performance compromise at all, anything which involves an artificial ceiling on quality, and this is why we are opposed to measures that would authorize the FCC to require specific filters in audio equipment.

Now, with the other point I raised before about the possibility of making meaningful standards for the electromagnetic fields in which

a given piece of equipment will operate, that is true for an isolated piece of equipment like a television set. Again, I should reiterate what Mr. Foster also said, that with a component in an audio system you can never tell what is going to happen because of interactions; even resonant lengths of cable connecting two pieces of equipment, just the length of the cable, can make the connecting cable act as an antenna. So there is another factor.

But even a television set does not work in a vacuum. It works with an antenna, and it works in a real environment. And I would like to enter into the record a brief passage from a book which I'm sure Mr. Dannals will recognize. It is the ARRL's Radio Amateur's Handbook, the 1976 edition. And there is a section back here in a chapter devoted to interference called, "Harmonics by Rectification." It says:

Even though the transmitter is completely free from harmonic output, it is still possible for interference to occur because of harmonics generated outside the transmitter. These result in rectification of fundamental frequency currents induced in conductors in the vicinity of the transmitting antenna. Rectification can take place at any point where two conductors are in poor electrical contact, a condition that frequently exists in plumbing, downspouting, BX cables crossing each other, and numerous other places in the ordinary residence.

I'm going to skip down here a little way to a point where it says, "Nothing can be done in either the transmitter or receiver when rectification occurs," meaning rectification in places like that. And when you're running a kilowatt, this is a problem.

Now, the book points out, quite rightly, that this happens most often in the ham service on the 28-megahertz band, which is very close to the citizens band, which is 27 megahertz. The reason for that is that the harmonics which are generated, the lower order harmonics, are the ones which would jam VHF television channels.

This raises a point about the wisdom of having CB in the 27-megahertz band and allowing it to continue there. It was a mistake to put CB there in the first place. It was a big mistake to make it an AM service rather than an FM service a few megahertz up.

[The following information was subsequently received for the record:]

HARMONICS BY RECTIFICATION

Even though the transmitter is completely free from harmonic output it is still possible for interference to occur because of harmonics generated outside the transmitter. These result from rectification of fundamental-frequency currents induced in conductors in the vicinity of the transmitting antenna. Rectification can take place at any point where two conductors are in poor electrical contact, a condition that frequently exists in plumbing, downspouting, BX cables crossing each other, and numerous other places in the ordinary residence. It also can occur at any exposed vacuum tubes in the station, in power supplies, speech equipment, etc., that may not be enclosed in the shielding about the rf circuits. Poor joints anywhere in the antenna system are especially bad, and rectification also may take place in the contacts of antenna changeover relays. Another common cause is overloading the front end of the communications receiver when it is used with a separate antenna (which will radiate the harmonics generated in the first tube) for break-in.

Rectification of this sort will not only cause harmonic interference but also is frequently responsible for cross-modulation effects. It can be detected in greater or less degree in most locations, but fortunately the harmonics thus generated are not usually of high amplitude. However, they can cause considerable interference in the immediate vicinity in fringe areas, especially when operation is in the 28-MHz band. The amplitude decreases rapidly with the order of the harmonic, the second and third being the worst. It is ordinarily found that even in

cases where destructive interference results from 28-MHz operation the interference is comparatively mild from 14 MHz, and is negligible at still lower frequencies.

Nothing can be done at either the transmitter or receiver when rectification occurs. The remedy is to find the source and eliminate the poor contact either by separating the conductors or bonding them together. A crystal wavemeter (tuned to the fundamental frequency) is useful for hunting the source, by showing which conductors are carrying rf and, comparatively, how much.

Interference of this kind is frequently intermittent since the rectification efficiency will vary with vibration, the weather, and so on. The possibility of corroded contacts in the TV receiving antenna should not be overlooked, especially if it has been up a year or more.

Mr. STRASSBURGER. What would happen to that portion of the spectrum if CB's were to take over?

Mr. HANNOLD. I don't know. You would have a madhouse for a while. Obviously, the FCC would have to allow an amortization period for today's CB equipment if anything like that were to be undertaken. I think 5 years is the customary period. That is what has happened with landmobile radio.

The current CB hardware could be used for other services, such as rescue operations, a low-cost marine band, a few other shared services; but the FCC should eliminate hobbyist radio operation with no test.

I should point out here that we are violating an international agreement which I don't think is acceptable under the Constitution; as long as we are signatories to an international agreement, we've got to honor it. And the FCC, by having dropped the restriction on hobby use of CB, is violating a treaty right now. We are bound by the articles of the International Telecommunications Union, and article 41 requires that no hobbyist operation be licensed by any signatory country below a frequency of 144 megahertz, unless there are tests for both technical knowledge and proficiency in sending and receiving telegraph code. We are violating that right now by allowing hobbyist operation on the 27-MHz band.

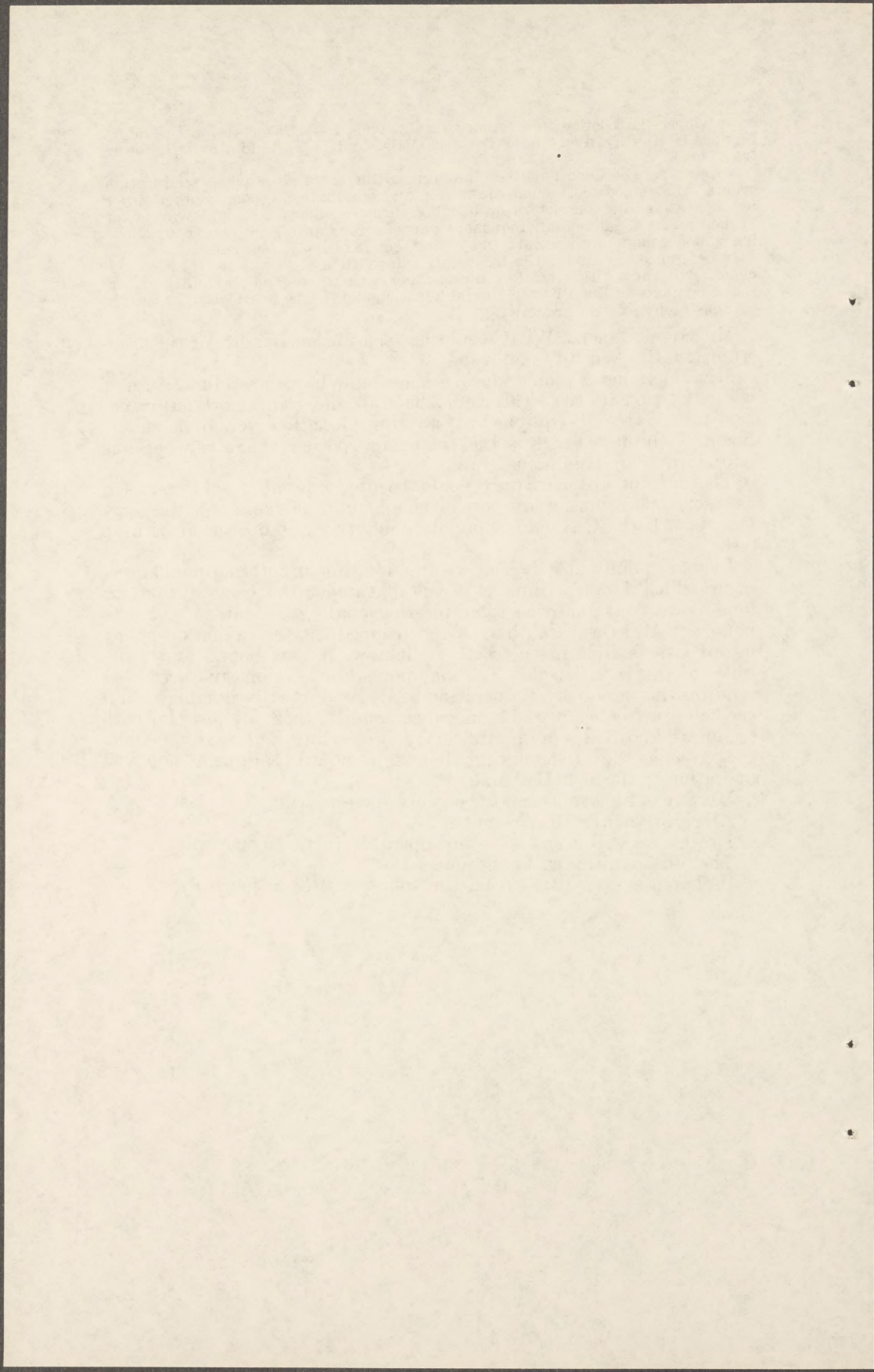
Mr. STRASSBURGER. Does anybody else have anything?

All right, thank you very much.

I think we will keep the record open for further comments.

The subcommittee will be adjourned.

[Whereupon, at 12:50 p.m., the subcommittee adjourned.]



ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

CONSUMERS UNION,
June 28, 1978.

HON. ERNEST F. HOLLINGS,

Chairman, Communications Subcommittee, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: Consumers Union¹ appreciates this opportunity to submit these comments in lieu of testimony for the hearing record on S. 864, a bill which would authorize the Federal Communications Commission (FCC) to prescribe regulations with respect to certain electronic equipment that is susceptible to radio frequency energy interference. S. 864 would amend Section 302 of the Communications Act of 1934 (47 U.S.C. 302a) by authorizing the Federal Communications Commission to issue regulations requiring the use of protective components on "consumer electronic equipment" for the purpose of reducing interference to such equipment from other radio frequency sources. The bill clarifies and makes explicit the Commission's power to set technical standards necessary to prevent interference to home electronic equipment.

Consumers Union would not endorse S. 864 in its present form. We would recommend that the Subcommittee address the concerns set forth below before the Subcommittee acts on the measure.

The bill's grant of authority to the Federal Communications Commission to assert jurisdiction over "consumer electronic equipment" may at once be too narrow and too broad. A definition of "consumer electronic equipment" should be supplied. For example, consumer electronic equipment could include portable pocket radios, pocket calculators, and even electronic components in washing machines. Certainly all of these items can be forced to misbehave in the presence of strong radio frequency fields. If the intent is to expand FCC jurisdiction to such a vast range of products, such intent should be clearly stated and concomitant commitment to providing the requisite funding and staff for such an endeavor should be included in the bill. At the same time, the proposed delegation of authority to the FCC may be too narrow. Given that electromagnetic interference seems to occur more frequently as devices capable of emitting electromagnetic radiation proliferate in the environment, one may also expect interference to such critical devices as the electronically controlled patient life support systems used in hospitals and to industrial equipment as well. The Subcommittee's intent with respect to such other devices should also be clarified.

In many instances, the proliferation of CB and amateur radio transmitters have been blamed for the increasing frequency of complaints to the FCC about radio frequency interference to other consumer products such as televisions, stereos, electric organs, etc. It should be noted that the performance standards currently applicable to CB and amateur radio transmitters are such that in any event it may be impossible to eliminate interference by merely attaching protective components to home receivers. For example, harmonics of the transmitter frequency which occur at the same frequency as the desired TV or FM station will be perceived as interference by the consumer. Any device that would weaken the interference signal would also, unfortunately, weaken the desired station as well. Consumers Union would recommend consideration of the imposition of more stringent specifications on the harmonic output of CB and ham transmitters.

¹ Consumers Union is a nonprofit membership organization chartered in 1936 under the laws of the State of New York to provide information, education, and counsel about consumer goods and services and the management of the family income. Consumers Union's income is derived solely from the sale of Consumer Reports, its other publications and films. Expenses of occasional public service efforts may be met, in part, by nonrestrictive, noncommercial grants and fees. In addition to reports on Consumers Union's own product testing, Consumer Reports, with more than 1.8 million circulation, regularly carries articles on health, product safety, marketplace economics, and legislative, judicial and regulatory actions which affect consumer welfare. Consumers Union's publications carry no advertising and receive no commercial support.

Also, Consumers Union would recommend vigilant FCC monitoring of the illegal devices which boost CB radio transmitter power output to limits well beyond the levels specified by the FCC. It may be that such illegal operation may also contribute to the substantial number of complaints received by the FCC from consumers.

The Subcommittee should also consider the potential problems involved in enforcing standards applicable to a market as vast as the "consumer electronic equipment" market. The FCC is a relatively small agency with, by Washington standards, a small budget. The expansion of FCC power over consumer electronic equipment may require a substantial increase in staff and funding in order for the FCC to make the enforcement of its rules meaningful. We would urge that the Subcommittee undertake an analysis of just what the required staff and funding levels would be.

Finally, there is the question of the impact on the price of consumer electronic equipment which would accompany the implementation of the rules authorized by the instant legislation. Obviously, the precise economic impact has not been measured at this point. Cost analysis and projections should be undertaken prior to the Committee's consideration of the bill.

In summary, Consumers Union would recommend that the Subcommittee considers the concerns raised in this letter and adequately develop a record addressing such concerns prior to the Subcommittee's final determination of the merits of S. 864.

Sincerely yours,

SHARON NELSON,
Legislative Counsel, Washington Office.

ELECTRONIC INDUSTRIES ASSOCIATION,
Washington, D.C., June 8, 1978.

SENATE COMMERCE COMMITTEE,
Subcommittee on Communications, Russell Senate Office Building, Washington, D.C.

GENTLEMEN: This letter is submitted on behalf of the Citizens Radio Section of the Communications Division of Electronic Industries Association (the Section), to be incorporated in the record of the subcommittee's hearings on S. 864. The Citizens Radio Section is composed of U.S. companies engaged in, or having an interest in, the manufacture and sale of radio equipment and accessories used in the Citizens Radio Service. A recent poll of members of our Citizens Radio Section indicates strong support for legislation such as S. 864.

CB has undergone an explosive growth from fewer than one million licenses ten years ago to over 13.3 million licenses today, and an estimated 30 million sets in use by licensees. Projections indicate the sale of over six million sets per year for the foreseeable future. The growth of citizens radio alone indicates the RF environment has changed dramatically in less than a generation and will continue to become more complex.

Because of the increasing density of interference-producing and interference-sensitive devices, we would suggest it is in the interest of the consuming public that as much be done as reasonably possible during the manufacturing process to minimize the possibility of interference. The cost of such "fixes" during the manufacturing process would appear to be significantly less than the cost to individuals to correct interference complaints in the field.

With regard to citizens radio equipment, when the rules for CB radio were first written in 1958, no one imagined the popularity of the service. Technical requirements were not stringent and home-built equipment was acceptable. As the service grew, interference problems attributed to transmitter characteristics became apparent and the Federal Communications Commission has acted repeatedly to revise and tighten technical requirements for citizens radio equipment. The incidental radiation requirements on CB receivers are several orders of magnitude more stringent than those applied to television receivers; and under a pending FCC Docket, the CB industry faces radiation requirements on transmitters which are equalled only by the most sophisticated military systems, even though the power radiated by CB is a tiny fraction of military radios. It has been observed that the search for the means to abate interference has brought our industry to the very edge of the state of the art.

We should not improve in RF susceptibility characteristics of consumer devices has taken place recently, but there is still far to go, particularly with

regard to consumer awareness levels. While we would prefer to see the problems addressed by S. 864 to be solved by voluntary action, and while we are loath to call for more government regulation, we do feel the legislation offers a practical means for attacking a major portion of the interference problem. Therefore, the Citizens Radio Section, Communications Division, Electronic Industries Association, favors S. 864.

Sincerely,

JOHN SODOLSKI,
Vice President, Communications Division.

UNITRON INDUSTRIES INC.,
Port Huron, Mich., June 28, 1978.

HON. ERNEST F. HOLLINGS,
Chairman, Senate Communications Subcommittee, Dirksen Senate Office Building, Washington, D.C.

DEAR SENATOR HOLLINGS: We have been in contact with Senators Griffin and Riegle regarding Senate Bill 864. Mr. Russell of Senator Griffin's office suggested that we write to you as Chairman of the Communications Subcommittee to express our concerns about this proposed legislation.

By way of introduction, Unitron Industries, Inc. was established in Port Huron, Michigan, almost four years ago. We import and nationally distribute the hearing aids manufactured by our parent company in Canada. Since our beginning we have been fortunate enough to expand our business consistently in an otherwise stagnant market brought about in part by uncertainties regarding the activities of various governmental regulatory agencies.

The purpose of this letter is to request your assistance in the matter of Senate Bill 864 which the Senate Communications Subcommittee presently has under consideration. As we understand the proposed legislation, it would cause hearing aids, among other electronic devices, to be regulated by the Federal Communications Commission as devices susceptible to radio frequency interference (R.F.I.).

In recent years R.F.I. has been a miniscule problem in this industry. In the case of the instruments manufactured by our company, it was long ago determined that the addition of a capacitor, in the proper location, eliminated the problem even for users living near radio and television transmitter sites. This capacitor has been routinely included in the design of all Unitron hearing aids for some years.

As you are undoubtedly aware, the Medical Device Amendments of 1976 placed hearing aids under the regulatory jurisdiction of the Federal Drug Administration as Class II (restricted) devices. We are required by the FDA to maintain a file of consumer complaints and the disposition of each complaint.

The single R.F.I. complaint we have received since opening the Port Huron facilities was from a user in Texas who complained of interference from a particular Citizens Band transmitter. His hearing aid was thoroughly tested using a legal CB transmitter at a distance of 1.0 meter and no interference could be detected.

It is virtually certain that the offending transmitter was equipped with an illegal linear amplifier that boosted its power output far above the limits allowed by FCC regulations.

It is our feeling that the FDA supervision is more than adequate to insure that any manufacture could correct any rare cases of R.F.I. that might occur.

If this legislation were enacted in its present form, all hearing aid manufacturers would, in order to protect themselves, be forced to purchase equipment costing several thousands of dollars to insure that a virtually non-existent problem did not occur. The additional financial burden on the hearing aid manufacturers, most of whom are small businesses, when added to the tens of thousands of dollars each of us has been forced to spend to insure compliance with the FDA regulations, can only further increase the cost of our products to the consumer without providing him with any commensurate benefit.

For the reasons outlined, we would respectfully urge that hearing aids be specifically exempted from the provisions of Senate Bill 864.

Thank you for your consideration of our concerns. If we can supply any additional information or assistance, please let us know.

Yours very truly,

WILLIAM D. HOOPER, *President.*

HEARING INDUSTRIES ASSOCIATION,
Washington, D.C., June 29, 1978.

HON. ERNEST F. HOLLINGS,
Chairman, Senate Subcommittee on Communications, 233 Russell Senate Office
Building, Washington, D.C.

DEAR SENATOR HOLLINGS: The Hearing Industries Association (HIA), the association of manufacturers of hearing aids and related components, submits the following comments on S. 864, which would authorize the Federal Communications Commission to regulate electronic equipment, including hearing aids, which is susceptible to radio frequency interference (RFI).

While HIA is not qualified to address the extent to which an RFI problem exists for other electronic equipment, we have surveyed our membership and found the frequency of RFI interference with hearing aids to be less than .05 percent. HIA has also asked the National Hearing Aid Society, the association of hearing aid dispensers, if they have received complaints from their members about radio frequency interference with hearing aids. Their response, which is attached, indicates that they have received no complaints about this to date.

With respect to the very few RFI complaints our members have received, the problem in each case we know of was remedied by the addition of a capacitor to the aid involved. Moreover, as hearing aids are a Class II restricted device regulated by the Food and Drug Administration under the Medical Device Amendments of 1976, we are required by the FDA to maintain a file of consumer complaints, with the disposition of each. Such a complaint handling procedure assures that RFI complaints are attended to by the hearing aid manufacturer.

HIA firmly believes that the miniscule amount of radio frequency interference with hearing aids, coupled with FDA's more than adequate supervision of hearing aids, makes it unnecessary to subject the hearing aid industry to further costly government regulation which could not help but increase the price of hearing aids.

Since it seems obvious that the committee is really concerned about the RFI problem as it applies to TVs and stereos, we urge you to make it clear to the FCC in any legislation or recommendations that you did not intend to subject the hearing aid industry to their regulation. For our part, the hearing aid industry will continue to conscientiously correct those few RFI problems which occur.

Respectfully submitted,

GLENN L. KENNEDY, *President.*

Enclosure.

NATIONAL HEARING AID SOCIETY,
Livonia, Mich., May 15, 1978.

Mr. WILLIAM SULLIVAN,
Hearing Industries Association, 1800 M Street NW., 10th Floor,
Washington, D.C.

DEAR BILL: In response to your inquiry, I am pleased to advise that we have reviewed our records and find that we have received no complaints regarding radio interference in hearing aids caused by adjacent radio transmitters.

While such interference is theoretically possible from a wide variety of sources, including Citizens Band activities, our members have not experienced a sufficient number of incidents to prompt them to register a concern with this office.

As you know, the National Hearing Aid Society represents approximately 3,600 of the total of slightly more than 7,000 hearing aid specialists. When you consider that in many instances, the owner of the dealership is an NHAS member, while his employees are not, we estimate that NHAS members and their employees sell in excess of 80% of the hearing aids sold each year.

I trust the above will serve to supply you with the information you require. If I can be of any further assistance, please do not hesitate to advise.

Sincerely yours,

ROBERT W. LEE,
Director of Governmental Relations.

GENERAL TELEPHONE & ELECTRONICS CORP.,
Washington, D.C., July 14, 1978.

Hon. ERNEST F. HOLLINGS,
Chairman, Senate Subcommittee on Communications, Russell Senate Office Building, Washington, D.C.

DEAR MR. CHAIRMAN: Based on a detailed analysis of the text of Senate Bill 864, introduced by Senator Goldwater on March 2, 1977, GTE, on behalf of its domestic telephone operating companies, submits the following comments for your consideration. GTE's manufacturing operations which might be affected, such as Sylvania, are working with such groups as the Electronics Industries Association (EIA) in commenting on the legislation.

The proposed bill amends the Communications Act to specifically include consumer electronic equipment in Section 302(a) of the Act, which presently empowers the FCC to promulgate rules and regulations concerning (electrical) interference to radio reception.

The proposed language "consumer electronic equipment", however, appears to be very broad and lacks definition. While we agree with the intent of the bill, which is aimed at minimizing harmful electromagnetic interference, we believe some additional definition is required to avoid potential misapplication or expansion into areas that the sponsors did not intend. As you are aware, the FCC has recently extended its control over telephone terminal equipment including telephones, data and ancillary devices, and key and PBX systems. Since these devices have been classed by the FCC as products available for purchase by the general public (i.e., consumers), it is not unreasonable to class such devices as "consumer electronic equipment." This indicates that an entire telephone industry and the suppliers of telecommunications terminal equipment may be affected by still further regulation beyond Part 68 of the current FCC Rules.

The telephone industry and its suppliers have long recognized the problem of susceptibility to electromagnetic interference (EMI) and have developed and adopted design and test standards to reduce such interference. Such standards have been in general use in the telephone industry for some time and are continually revised and updated to keep pace with network performance improvements and the ever-changing state of art in technology. Should telephone terminal equipment/systems be classed as "consumer electronic equipment," we believe there would be problems in insuring that Federally mandated regulations keep pace with the evolution of the telecommunications industry.

In addition, industry standards, which are more suitable to the needs of the telecommunications industry, have been developed by such bodies as the EIA and the Institute of Electrical and Electronics Engineers (IEEE).

For the reasons just stated, GTE recommends that the language of the proposed bill be amended to incorporate a definition of consumer electronic equipment that specifically excludes telecommunications equipment covered by Part 68 of the Commission's present Rules, 47 CFR 68.1 *et seq.*

Respectfully submitted,

WILLIAM MALONE.

STATEMENT OF NATIONAL ASSOCIATION OF BROADCASTERS

The National Association of Broadcasters is a trade association representing television and radio licensees and networks. As such, we are vitally concerned over the amount of television interference that is experienced by the people of this nation.

As a trade association, representing nearly 5,000 broadcasters, the NAB is in constant contact with those who transmit radio and television signals, and those who receive them. In recent years we have been made aware of increasing interference in the reception of these signals. Station managers, engineers and others have indicated to us that these problems seem to be ever more serious. In addition, the general public has complained to many of our members about the state of television and radio signal reception.

We should point out that the first reaction to such problems by many members of the public is to call the radio or television station responsible for transmitting the signal they are receiving. Many of these viewers or listeners are quite unhappy about the poor reception caused by interference from CB radio users. While station representatives try to explain the reason for the interference it continues to be difficult to deal with the problem, particularly after it is pointed

out that the set could be constructed in a way that would prevent such interference.

There are two ways to attack this problem. First, the solution could come from better design of the CB transmitting set to cut down on the amount of interference at the receiving end. The NAB believes that such an approach would be the most equitable way to deal with interference problem. Since there are several times as many receivers affected by CB interference as transmitters, it would seem that an adjustment at the point of transmission would cause the least confusion.

The second way to attack the problem is to approach it as Senator Goldwater does in S. 864. This would solve the problem at the receiver end. The NAB commends the filing of this legislation since it makes an attempt to solve what is a persistent and irritating problem.

Many sets manufactured today are constructed so as to take care of the great majority of interference problems. This legislation would give to the FCC the authority to require the proper changes in all sets so that these interference problems could eventually be corrected.

We would hope the Congress would consider Mr. Goldwater's approach to this problem, and that if a proper solution with the transmitting equipment cannot be devised, strong consideration will be given to S. 864 so that this problem can be solved in the near future. We thank the committee for this opportunity to present our views.

STATEMENT OF DAVID SIDDALL, PRESIDENT, AND MORTON BLENDER, VICE PRESIDENT,
THE CAPITOL HILL AMATEUR RADIO SOCIETY

The Capitol Hill Amateur Radio Society is a club of licensed amateur radio operators who work for the United States Senate, United States House of Representatives, Library of Congress, or Supreme Court. For a number of years the Society has maintained an amateur radio station on Capitol Hill which is capable of communication with any area of the world. Amateurs from all fifty states and over one hundred countries have contacted our station on the shortwave frequencies and have received certificates confirming that communication. Besides spreading goodwill by speaking directly with amateurs in all parts of the nation and world from the seat of government, the station has assisted in handling communications to the Washington, D.C. area from areas of natural disaster on several occasions. The station stands ready with her sister stations at the Department of State and at the Pentagon to assist in any emergency communications necessary. All of the station's equipment is donated or lent to the club by its members, and related costs are paid from club dues.

OUR VIEWS

The views expressed herein are solely the views of the Society, and are not to be imputed to the employer or employers of any of its members.

SCOPE OF REMARKS

Working on Capitol Hill in various capacities ourselves, we respect the fact that the Subcommittee's time is limited. Herein we refrain from citing the facts and figures and outlining the pervasive incompatibility problems between radio transmitters and electrical devices present in neighborhoods everywhere across the nation. These facts, figures, and examples will be presented by other witnesses appearing before you today. We therefore concern ourselves with outlining why it is in the public interest to enact S. 864.

NECESSARY FOR RADIO INTERFERENCE LEGISLATION

S. 864

S. 864 would amend the Communications Act of 1934 to authorize the Federal Communications Commission to prescribe regulations with respect to certain consumer electronic equipment that is susceptible to radio frequency energy interference.

Communications Act of 1934, as amended

The very foundations of the Communications Act of 1934 rest upon the need to minimize interference. The Radio Act of 1912 had been passed "for the purpose of preventing or minimizing interference," but subsequent court decisions determined that under this law anyone could transmit after receiving a license from the Secretary of Commerce—and the Secretary had no authority to deny a license. Since the radio spectrum is limited, interference between signals

became increasingly severe. Thus the Radio Act of 1927 was passed to empower a Federal Radio Commission to regulate the airwaves in such a manner as to minimize interference.

The Communications Act of 1934, as amended and in force today, contains a number of provisions which specifically grant the Federal Communications Commission authority to regulate interference. For instance, Section 302a authorizes the Commission to "make reasonable regulations governing the interference potential of devices which in their operation are capable of emitting radio frequency energy . . . [which could] cause harmful interference to radio communications." Section 303(f) authorizes the Commission to "make such regulations not inconsistent with law as it may deem necessary to prevent interference between stations and to carry out the provisions of this Act."

The present law appears to regulate interference caused by a transmitting station. Although there is some evidence that interference problems caused by receivers rather than transmitters were brought to the House of Representatives' attention in hearings on the Radio Act of 1927, it is not apparent from the record whether the Congress intended to regulate interference by regulating all communications devices or just transmitters. Amendments to the Act in 1968, now within Section 302a of the Act (See page 3.), included language to regulate only those devices which emit radio frequency energy.

The Federal Communications Commission has determined that under the present Act it lacks statutory authority to regulate the susceptibility of home electronic entertainment equipment to radio frequency interference. (Home electronic entertainment equipment is defined by the Commission at page 1 of its July, 1977 report on "The Extent and Nature of Television Reception Difficulties Associated With CB Radio Transmissions," FCC/FOB/PD&E 77-02, as including "AM, FM, TV, and other receivers, audio devices such as tape recorders, electronic organs, phonographs and other electronic equipment commonly used in the home.")

FCC's CB/TVI Study

In the CB/TV interference report referenced above, the Commission's "best estimate" of the number of individuals affected by interference is 4,000,000 for 1976. They estimate that this number will increase to 9,000,000 by 1979. Seventy-six percent of those affected involve home electronic entertainment equipment. Assuming that the same percentage of home electronic entertainment equipment is susceptible to interference due to its design characteristics, rather than to transmitter deficiency, as in the Commission's report, 45 percent of the problems with such equipment would be solved by appropriate design. Thus, of an estimated 3,000,000 individuals who experienced radio frequency interference problems with their home electronic entertainment equipment in 1976, 1,350,000 would not have experienced any problem had this legislation been in force. This is the Commission's own conservative estimate.

For 1979 the Commission's best estimates are that 7,000,000 individuals will experience interference to their home electronic entertainment equipment. Of these, 3,150,000 would not have experienced the problem if this legislation were passed and applicable to the units in service.

It must be noted that the above are interpolated from the Commission's "best estimates" as presented in the July, 1977 reported referenced on page 4. Commission projections range all the way up to 16,000,000 individuals affected, of which 7,200,000 would not experience the problem if this legislation is passed and applicable to the units in service.

The public interest

We believe that enactment of the legislation is in the public interest because, according to the Commission's own conservative figures, it would eliminate approximately 45 percent of the radio frequency interference problems experienced by individuals with their televisions, radios, tape recorders, electronic organs, phonographs, and other electronic equipment, such as home computers and video games. The use of such equipment in homes is expected to continue to increase over the next few years.

We note that the Commission has already taken efforts to clean up the radio spectrum. Up until the time of the July, 1977 CB/TVI study, the Commission believed that some 90 percent of all home interference problems were caused by deficiencies in the home electronic entertainment equipment itself. At least partly as a result of the findings of this study, the Commission has issued more stringent technical standards for citizen band radios and radio amateur amplifiers. In addition, in an overly broad regulation, the Commission has prohibited the sale of radio amateur amplifiers capable of operation in the citizens' eleven

meter band and the amateurs' ten meter band. (Amplifiers boost a transmitter's power beyond legal CB limits, but such power is legal in the amateur service.)

S. 864 must be passed to complete the cleanup of interference problems. It is important that this legislation be passed as soon as possible in order to stop and reverse the geometrically increasing number of both complaints to the Commission and irritating annoyances to all of us in our neighborhoods.

Complaints to the commission

For years individuals complaining to the Commission about radio frequency interference received FE Bulletin No. 24 or No. 25 in return. Both bulletins basically told the person experiencing interference with his or her equipment to consult a service technician. The Commission received an estimated 100,000 radio frequency interference complaints in 1977 alone. We understand the Commission's problems in merely answering such a volume of mail. The Commission itself admits it is unable to begin to investigate the individual complaints.

Commission's position on S. 864

In 1974 the Commission apparently gave consideration to requesting legislation to deal with the radio frequency interference problems caused by the deficient design of many home electronic entertainment devices, according to a letter from then-Chairman Wiley to Congressman Vanik. Later that same year, Mr. Raymond Spence, the Commission's Chief Engineer, stated before the I.E.E.E. Chapter Group of Electromagnetic Compatibility on November 22, 1974: "We are going to keep pushing for, and asking for whatever enabling and supporting legislation is necessary. Assuming we get that, then we will look at it at that time and see what still remains to be done and propose the necessary rules." However, no request for such legislation was forthcoming.

On June 8, 1978 the Commission voted to take no stand on S. 864. Perhaps the Commission mistakenly believes that its actions to clean up one-half of the problems are sufficient. But we would point out that if the more than doubling of complaints over the past three years continues, the measures taken so far by the Commission can be expected to do no more than put a temporary dent in the upward curve of complaints. Instead of the Commission's own conservative estimate of 200,000 complaints in 1979, it might be 1980 before the 200,000 per year mark is reached.

Should this result be accepted instead of cleaning up the problem as much as possible now? We think not. And we point out that the members of home electronic entertainment devices are rapidly rising. Ultimately this legislation will become an overriding necessity, yet each year's delay increases the ultimate cost of initiating action. And each year legislation is not passed results in increasing numbers of complaints that must be handled by the Commission's Enforcement Division. The annual cost is currently over \$1,000,000. Some complaints reach the courts at further cost. All of them increasingly irritate both the radio operator and the neighborhood residents.

The public's radio frequency interference problem

Would you be irritated if in the middle of the night your clock radio began emitting garbled sounds? Or if at church on Sunday morning the electronic organ speakers interrupted the sermon with "Get that son-of-a-gun—he just went through the light down at 33rd"? How about if you sat down at your color television to watch the Super Bowl and instead got nothing but lines across the screen and noises from the speaker caused by a neighbor down the block?

You probably wouldn't like it. But let's look at the other side of the story.

Would you enjoy talking on your CB or ham radio if you knew it might wake up your neighbor? Would you be embarrassed if you found out that your half of a conversation with your wife over the CB was broadcast to 150 of your neighbors at a church service when you were stopped at a red light in front of the church? Or would you call a dear old friend you hear on the radio for the first time in months if you suspect your neighbor's television set might malfunction in the middle of the Super Bowl as a result?

Radio frequency interference is an irritant, to say the least, to both sides in any situation. To add to the problem, there is always the question of who is at fault. It is the amateur, CBer, policeman, fireman, or other spectrum user whose equipment is operating properly? Or is it the consumer, whose hard earned dollars have gone towards a home electronic entertainment device that is incapable of correctly operating in radio frequency energy fields?

The manufacturers have traditionally argued that less than one percent of their devices can be expected to be placed in a strong radio frequency field. A map of Arlington, Virginia prepared by the Commission itself some years ago, before the current CB explosion, shows that any device sold for use in that area has at least a 50/50 chance of being in such a strong radio frequency field. Today we suspect the percentage would be much higher—except maybe around Arlington Cemetery!

Radio frequency interference in the courts

Kenneth Wideltitz, President of the Personal Communications Foundation (10960 Wilshire Boulevard, Suite 1504, Los Angeles, California 90024), estimates that he hears of a court case a week concerning radio frequency interference. The Foundation collects and disseminates legal information of concern to personal radio users. In one recent case he brought to our attention, as a representative sample, *People v. Peeks* (case No. 78W 2567, Municipal Court of West Orange County Judicial District, Orange County, California), the defendant was charged with creating a public nuisance by "transmitting her voice over the airwaves in such a manner and with such equipment that interfered with the use of telephones, radios, and stereo equipment by a considerable number of people." When the defendant won that case upon a demurrer, a new case was filed, Nos. 78W 3484, 78W 3485, and 78W 3486, alleging that her actions violate a section of the California Penal Code.

The final outcome of the *Peek* case won't be significant to Marvin Wade of Bartlett City, Tennessee. Mr. Wade was found guilty in municipal court of violating the Bartlett noise ordinance and of maintaining a public nuisance. According to a news article about this case in the March 31, 1978 edition of *The Commercial Appeal of Memphis, Tennessee*, this action followed neighbor complaints to the police that Mr. Wade's CB transmissions were being picked up on radios, televisions, and telephones in the neighborhood. A neighbor stated that interference to his daughter's radio began at 6:00 a.m. one day. Another said he woke up in the middle of one night to voices and thought someone was in his bedroom. The voices were radio transmissions coming in over his home intercom system. The newspaper dryly notes that since the CB boom during the last five years "voices and noises have invaded homes all over the County." The newspaper article states that it receives "a number of complaints each month from irate readers who have been invaded by the 'aggravating voices,' and don't feel they should have to spend money to correct their sets."

There are two sides to every story. In this type of case a licensed individual may understandably be inhibited from operating his properly functioning equipment if it interferes with his neighbors' home entertainment devices. Maybe the possibility of legal action is not appealing. It may be easier to sell the radio transmitting equipment and give up the thought of convenient communications between home and car or hobby communications around the world. This might appear to be a sort of a solution, but it is necessary to ask: is it in the public interest to in effect deny citizens their apparent right to operate CB and amateur radios? Would it be in the public interest to prohibit two-way radio use by airports, airplanes, police and fire personnel, satellite tracking stations, the military, etc. in order to enable homeowners uninterrupted use of home electronic entertainment devices? Or is there a way for both communications transmitters and consumer electronic equipment to coexist?

Solutions to radio frequency interference

Amateur

There is one thing that amateurs learn very early in the game: home entertainment devices could have incorporated radio frequency interference protection during their manufacture at little cost. Experience has demonstrated to the amateur community that simple filters and by-passing and shielding techniques, if designed into original equipment, would eliminate most of the home electronic entertainment equipment consumer complaints.

One of the authors of these comments, for instance, made a practice of tape-recording FM broadcasts of the Boston Symphony Orchestra. His house was near the approach path of commercial airlines coming into the Providence, Rhode Island area. Two or three times a program, Beethoven was accompanied by runway numbers, wind velocities, and flight numbers. This situation could not call for a request to the tower or to the pilot to get out of the way of the Boston Symphony Orchestra! The solution was simply lining the wooden cabinet of the

FM tuner with heavy aluminum foil. Not all radio frequency interferences problems are that easily solved, but a great majority of them could be by the simple application of known techniques at the factory and, usually, at a much lower cost than by any other means.

Naval

There is one case at hand that will make it stunningly clear as to what we are dealing with and the logical route for remedial measures. The Engineering Division of the Naval Air Systems Command has a program called HERO-Hazards of Electromagnetic Radiation to Ordnance. Many types of naval weapons use electro-explosive devices (EED's) that, on shipboard or on shore, come within strong local magnetic fields. The EED is a small electric heater embedded in a temperature-sensitive explosive. When a missile or weapon is in an electromagnetic environment, stray RF currents may be induced into the firing circuit of the EED causing it to activate prematurely, possibly detonating the weapon itself. The Navy says there are two main avenues to overcome this problem:

- (1) cease transmitting when missiles or weapons are being handled, or
- (2) "fix" the missile or weapon so that stray currents cannot be induced into the EED's.

To cease transmitting would be unthinkable. Can you imagine a Navy strike force getting the order to shut down all radio, radar, sonar, Loran, inter-ship, and intra-ship communications every time a sensitive weapon was on deck? Of course not. Therefore, the HERO program was set up to engineer into the EED's protection against radio frequency fields.

Now apply that same concept to the community at large. No one expects broadcasting stations, airport towers, police, fire, and business radios to shut down at any time. Government and military installations operate twenty-four hours a day.

Manufacturers of home electronic entertainment equipment

It should be noted that to their credit a number of reputable manufacturers of such equipment will supply and/or install such protection in their products on a case-by-case basis free of charge. Others will do so for a minimal charge. A booklet on radio frequency interference recently published by the Commission incorporates a list of manufacturer contacts for such service. The list was compiled by the American Radio Relay League's R.F.I. Task Group. Mr. Morton Blender, an author of these remarks, is presently Secretary of this Group.

Mr. David Siddall, the other author of these comments, knows of a certain manufacturer of a popular clock radio that has repaired five units from the same neighborhood during the last year! This particular manufacturer has performed this task at no charge, but unfortunately many other manufacturers do not consider it their responsibility to do so.

Why isn't the shielding or protection built in for all units? Probably because up until the CB radio boom of the past five years it was profitable to leave such protection out; the small number of complaints could be rectified economically.

But now the numbers game has significantly changed. As the map of Arlington, Virginia on a previous page demonstrates, a unit's chances of being placed in a strong radio frequency energy field is much greater today. And remember, that map is nine years old and thus pre CB-explosion.

We understand the manufacturer's concern that a dime saved in parts might mean seventy cents saved on the unit's retail price. The home electronic entertainment equipment market is highly competitive. This legislation is, we believe, in the interest of the manufacturer as well as the general public. All will be under the same regulation. None will be given a competitive edge.

Consumer's Reports has begun to specifically rate some of the products it reports on for radio frequency energy susceptibility. Unfortunately, only a few manufacturers have introduced pretty much interference proof units. The Consumer's Reports action might help, but its effect upon the actual marketplace is unknown. All manufacturers should be placed on the same footing to insure fairness to them while at the same time insuring the consumer a product capable of operating in today's radio frequency environment.

CONCLUSION

The Communications Act of 1934 deals with emission-caused interference. The growth of personal communications led to problems with consumer electronic products interference in the homes of both the personal communicators and their neighbors.

The popularity of solid State electronic equipment resulted in more devices susceptible to radio frequency interference. The solid state devices themselves, however, when mounted on printed circuit boards and mounted in plastic cases, are more prone to radio frequency interference than the older vacuum tube units mounted on metal chassis.

Thus the simultaneous popularity of personal communications and solid state home entertainment equipment has resulted in huge numbers of complaints both to the Federal Communications Commission and, to a lesser degree, to you Senators.

In 1974 the Commission indicated that it would seek legislation similar to S. 864. Nothing has been forthcoming, and indeed, on June 8, 1978 the Commission decided to take no position on S. 864. This apparent shift in position, despite the rising costs of handling increasing numbers of complaints, is unfortunate and, we believe, at least in part due to the Commission's mistaken belief that the measures it has taken to regulate transmitters are adequate. The Commission appears to have ignored its own latest study on interference which shows that its measures are unlikely to affect at least 45 percent of the problem. Geometrically rising numbers of complaints will make it appear that little or no progress has been made.

Meanwhile our nation's citizens, including you and us, remain vulnerable to an unexpected strike of radio frequency interference. It is possible that you will be the next victim to be awakened in the middle of the night by strange voices coming out of your intercom or your clock radio or the speakers to your stereo.

Some CBers and amateurs have had their homes sabotaged and their families harrassed due to radio frequency interference problems which they were helpless to prevent. In many cases the problem is caused by neighbors' inadequately protected but expensive equipment. The seriousness of the problem has escalated to the point where now court action is likely to result.

Radio amateurs must pass an extensive test on electronics in order to earn their license. Thus, many radio amateurs such as Mr. Jarrett, who appeared before you today, know what to do to alleviate the problem. But Mr. Jarrett was fortunate in having a cooperative neighbor. Not all neighbors are still friendly after suffering through multiple instances of radio frequency interference.

The Navy's HERO program is an example which demonstrates that any equipment may be made impervious to radio frequency energy. We don't suggest that all home electronic equipment be protected as well as the Navy's ordnance, but we do suggest that simple, inexpensive measures incorporated into the design of consumer electronic equipment will eliminate most of the problems around a properly operating transmitter at CB, amateur, or public service power levels.

S. 864 would mandate the same level of protection for all consumer electronic equipment. All manufacturers would be treated equally.

This legislation would protect the consumer from home electronic equipment which malfunctions everytime an airplane passes overhead, or a police car passes on the street, or a CB or amateur neighbor begins transmitting.

For these reasons the Capitol Hill Amateur Radio Society concludes that prompt enactment of S. 864 is in the public interest. The consumer, the manufacturer, and the communicator will all be well served by this bill.

STATEMENT OF THE MOTOR VEHICLE MANUFACTURERS ASSOCIATION OF THE UNITED STATES, INC.

The Motor Vehicle Manufacturers Association of the U.S., Inc. (MVMA)¹ appreciates the opportunity to submit comments for the hearing record of the Senate Communications Subcommittee on S. 864 relating to radio frequency interference. We would like to comment on one key aspect of the interference issue: the need for the Federal Government to define the electromagnetic environment.

Advancements in the field of electronics, particularly the rapid development of micro-electronics, have proliferated electronic devices into many previously unforeseen applications, resulting in better performance and lower cost to the consumer. Factors such as improved durability, greater reliability, increased

¹ MVMA members include: American Motors Corporation; Checker Motors Corporation; Chrysler Corporation; Ford Motor Company; Freightliner Corporation; General Motors Corporation; International Harvester Company; Nolan Company; PACCAR, Inc.; Walter Motor Truck Company; and White Motor Corporation.

capabilities, lower power requirements, and lower cost, have been responsible for the increased use of electronic devices in place of other types of devices historically used in many diverse applications. As a result, the application of electronic devices is rapidly expanding in such fields as automotive, medical, entertainment, communications process controls and manufacturing.

However, the use of electronic devices is not without inherent problems. As the number of electronic devices increases, so does the number of potential sources of electromagnetic radiation into the environment. And, as the use of electronic devices increases, so does the number of electronic systems potentially susceptible to the effects of that radiation.

The proper design and installation of any device intended to operate properly under various conditions is predicated on a number of factors, including thorough knowledge of the intended or anticipated operating environment. Fortunately, in most cases, information defining many of the existing or predicted environment parameters is readily available for design purposes. For example, information regarding average and expected ranges of temperature, humidity, precipitation, wind speed, barometric pressure, etc., is compiled by various government agencies in a comprehensive manner and is periodically updated as required. However, there is a paucity of readily available information concerning the existing or anticipated electromagnetic field environment.

It is the MVMA position that appropriate techniques should be developed to define electromagnetic field environment. These should include techniques for determining the spatial distribution, frequencies, field strengths, types of modulation and other important characteristics of all significant electromagnetic radiations. These techniques should then be used periodically to obtain data describing the existing and anticipated electromagnetic field environments. These data should be compiled and made available to all interested parties.

Electromagnetic field environment data are needed by a large, diverse group of important industries, e.g., the automotive, medical, communications and entertainment industries. The Federal Government has the most knowledge of the locations, powers, radiation patterns, modulation types, frequencies and other significant characteristics of many important kinds of transmitters, e.g., broadcast, radar, military, industrial machinery, diathermy and mobile. Therefore, the Federal Government is in the best position to define the electromagnetic environment.

MEMORANDUM

TV OR TELEVISION INTERFERENCE

TVI or television interference has become a rather common problem among television owners across this country. There is nothing unusual about this nor was it unanticipated. There are three basic types of TVI. (1) Overloading of the TV set by transmitter fundamental. (2) Impairment of the picture by spurious emissions. (3) Impairment of the picture by the radiation of harmonics.

TV set overloading

Even if the amateur transmitter were perfect and had no harmonic radiation or spurious emissions whatever, it still would be likely to cause overloading to TV sets whose antennas were within a few hundred feet of the transmitting antenna. This type of overloading is essentially the same as the common type of BCI encountered when operating a medium-power or high-power amateur transmitter within a few hundred feet of the normal broadcast receiver. The field intensity in the immediate vicinity of the transmitting antenna is sufficiently high so that the amateur signal will get into the BC or TV set either through overloading of the front end, or through the i-f, video, or audio systems. A characteristic of this type of interference is that it always will be eliminated when the transmitter temporarily is operated into a dummy antenna. Another characteristic of this type of overloading is that its effects will be substantially continuous over the entire frequency coverage of the BC or TV receiver. Channels 2 through 13 will be affected in approximately the same manner.

With the overloading type of interference, the problem is simply to keep the fundamental of the transmitter out of the affected receiver. Other types of interference may or may not show up when the fundamental is taken out of the TV set (they probably will appear), but at least the fundamental must be eliminated first.

The elimination of the transmitter fundamental from the TV set is normally the only operation performed on or in the vicinity of the TV receiver. After the fundamental has been eliminated as a source of interference to reception, work may then be begun on or in the vicinity of the transmitter toward eliminating the other two types of interference.

Taking out the fundamental

More or less standard BCI-type practice is most commonly used in taking out fundamental interference. Wavetraps and filters are installed, and the antenna system may or may not be modified so as to offer less response to the signal from the amateur transmitter. In regard to a comparison between wavetraps and filters, the same considerations apply as have been effective in regard to BCI for many years; wavetraps are quite effective when properly installed and adjusted, but they must be readjusted whenever the band of operation is changed, or even when moving from one extreme end of a band to the other. Hence, wavetraps are not recommended except when operation will be confined to a relatively narrow portion of one amateur band. However, figure 1 shows two of the most common signal-trapping arrangements.

High-pass filters

High-pass filters in the antenna lead of the TV set have proven to be quite satisfactory as a means of eliminating TVI of the overloading type. In many cases when the interfering transmitter is operated only on the bands below 7.3 MHz, the use of a high-pass filter in the antenna lead has completely eliminated all TVI. In some cases the installation of a highpass filter in the antenna transmission line and an a-c line filter of a standard variety has proven to be completely effective in eliminating the interference from a transmitter operating in one of the lower-frequency amateur bands.

In general, it is suggested that commercially manufactured high-pass filters be purchased. Such units are available from a number of manufacturers at a relatively moderate cost. However, such units may be home constructed; suggested designs are given in figures 2 and 3. Types for use both with coaxial and with balanced transmission lines have been shown. In most cases the filters may be constructed in one of the small shield boxes which are on the market. Input and output terminals may be standard connectors, or the inexpensive type of terminal strips usually used on BC and TV sets may be employed. Coaxial terminals should of course be employed when a coaxial feed line is used to the antenna. In any event, the leads from the filter box to the TV set should be very short, including both the antenna lead and the ground lead to the box itself. If the leads from the box to the set have much length, they may pick up enough signal to nullify the effects of the high-pass filter.

Blocking from 50-MHz signals

Operation on the 50-Mc. amateur band in an area where channel 2 is in use for TV imposes a special problem in the matter of blocking. The input circuits of most TV sets are sufficiently broad so that an amateur signal on the 50-MHz band will ride through with little attention. Also, the normal TV antenna will have quite a large response to a signal in the 50-MHz band, since the lower limit of channel 2 is 54-MHz.

High-pass filters of the normal type simply are not capable of giving sufficient attenuation to a signal whose frequency is so close to the necessary passband of the filter. Hence, a resonant circuit element, as illustrated in figure 1, must be used to trap out the amateur field at the input of the TV set. The trap must be tuned, or the section of transmission line cut, if a section of line is to be used for a particular frequency in the 50-MHz band. This frequency will have to be near the lower frequency limit of the 50-MHz band to obtain adequate rejection of the amateur signal while still not materially affecting the response of the receiver to channel 2.

Elimination of spurious emissions

All spurious emissions from amateur transmitters (ignoring harmonic signals for the time being) must be eliminated to comply with FCC regulations. But in the past many amateur transmitters have emitted spurious signals as a result of key clicks, parasitics, and overmodulation transients. In most cases the operators of the transmitters were not aware of these emissions since they were radiated only for a short distance and hence were not brought to his attention. But with one or more TV sets in the neighborhood it is probable that such spurious signals will be brought quickly to the attention of the operator.

After any condition of blocking at the TV received has been eliminated, and when the transmitter is completely free of transients and parasitic oscillations, it is probable that TVI will be eliminated in certain cases. Certainly general interference should be eliminated, particularly if the transmitter is a well-designed affair operated on one of the lower frequency bands, and the station is in a high-signal TV area. But when the transmitter is to be operated on one of the higher frequency bands, and particularly in a marginal TV area, the job of TVI-proofing will just have begun. The elimination of harmonic radiation from the transmitter is a difficult and tedious job which must be done in an orderly manner if completely satisfactory results are to be obtained.

First it is well to become familiar with the TV channels presently assigned, with the TV intermediate frequencies commonly used, and with the channels which will receive interference from harmonics of the various amateur bands. Figures 4 and 5 give this information.

Even a short inspection of figures 4 and 5 will make obvious the seriousness of the interference which can be caused by harmonics of amateur signals in the higher frequency bands. With any sort of reasonable precautions in the design and shielding of the transmitter it is not likely that harmonics higher than the 6th will be encountered. For this reason, the most frequently found offenders in the way of harmonic interference will almost invariably be those bands above 14 MHz.

Nature of harmonic interference

Investigations into the nature of the interference caused by amateur signals on the TV screen, assuming that blocking has been eliminated as described earlier in this chapter, have revealed the following facts:

1. An unmodulated carrier, such as a c-w signal with the key down or an a-m signal without modulation, will give a crosshatch or herringbone pattern on the TV screen. This same general type of picture also will occur in the case of a narrow-band f-m signal either with or without modulation.

2. A relatively strong a-m or SSB signal will give in addition to the herringbone a very serious succession of light and dark bands across the TV picture.

3. A moderate strength c-w signal without transients, in the absence of overloading of the TV set, will result merely in the turning on and off of the herringbone on the picture.

To discuss condition 1 above, the herringbone is a result of the beat note between the TV video carrier and the amateur harmonic. Hence the higher the beat note the less obvious will be the resulting crosshatch. Further, it has been shown that a much stronger signal is required to produce a discernible herringbone when the interfering harmonic is as far away as possible from the video carrier, without running into the sound carrier. Thus, as a last resort, or to eliminate the last vestige of interference after all corrective measures have been taken, operate the transmitter on a frequency such as that the interfering harmonic will fall as far as possible from the picture carrier. The worst possible interference to the picture from a continuous carrier will be obtained when the interfering signal is very close in frequency to the video carrier.

Isolating the source of interference

Throughout the testing procedure it will be necessary to have some sort of indicating device as a means of determining harmonic field intensities. The best indicator for field intensities some distance from the transmitting antenna will probably be the TV receiver of some neighbor with whom friendly relations are still maintained. This person will then be able to give a check, occasionally, on the relative nature of the interference. But it will probably be necessary to go periodically and personally check the results obtained, since the neighbor probably will not be able to give any sort of a quantitative analysis of the progress which has been made.

An additional device for checking relatively high field intensities in the vicinity of the transmitter will be almost a necessity. A simple crystal-diode wavemeter, shown in Figure 6, will accomplish this function. Also, it will be very helpful to have a receiver, with an S meter, capable of covering at least the 50- to 10-MHz range and preferably the range to 216 MHz. This device may consist merely of a station receiver and a simple converter using the two halves of a 6J6 as oscillator and mixer.

The first check can best be made with the neighbor who is receiving the most serious or the most general interference. Turn on the transmitter and check all channels to determine the extent of the interference and the number of channels affected. Then disconnect the antenna and substitute a group of 100-watt lamps as a dummy load for the transmitter. Experience has shown that eight 100-watt lamps series-connected in two groups of four in parallel will take the output of a kilowatt transmitter on 28 MHz if connections are made symmetrically to the group of lamps. Then note the interference. Now remove plate voltage from the final amplifier and determine the extent of interference caused by the exciter stages.

In the average case, when the final amplifier is a beam-tetrode stage and the exciter is relatively low-powered and adequately shielded, it will be found that the interference drops materially when the antenna is removed and a dummy load substituted. It will also be found in such an average case that the interference will stop when the exciter only is operating.

Transmitter power level

It should be made clear at this point that the level of power used at the transmitter is not of great significance in the basic harmonic reduction problem. The difference in power level between a 20-watt transmitter and one rated at a kilowatt is only a matter of about 17 db. Yet the degree of harmonic attenuation required to eliminate interference caused by harmonic radiation is from 80 to 120 db, depending on the TV signal strength in the vicinity. This is not to say that it is not a simpler job to eliminate harmonic interference from a low-power transmitter than from a kilowatt equipment. It is simpler to suppress harmonic radiation from a low-power transmitter simply because it is a much easier problem to shield a low-power unit, and the filters for the leads which enter the transmitter enclosure may be constructed less expensively and smaller for a low-power unit.

The former was copied from the Radio Handbook whose author is William I. Orr, a very well-recognized authority on the subject. In addition to television interference, I have witnessed interference with organs, public address systems, and even telephones. With this paper I am including a diagram showing the harmonics to be expected on certain channels of present-day television. I might say that this whole subject of harmonics is a very interesting one and experts have been working on it for years and have come to general conclusion that there is not much you can do about eradicating harmonics, but you can, more or less, control them.

I recall one instance when automatic garage doors in Detroit were opening seemingly on their own but, come to find out, the Air National Guard was using a frequency and one of the harmonics of that frequency coincided with the frequency of the door receivers and the doors were opening. There has been some interesting work done on this by the Army, and it would be possible to get the results of these tests run on the most frequency-clear range in America, that area generally below Gila Bend, Arizona. This study was made about ten years ago, and I'm sure a call to the Army Signal Corps would bring forth some papers on the general subject. I have prepared this just for the information of the subcommittee, and I will send one to each member and also to the staff so that when we approach the hearings we will have a better idea of what we are getting into.

RE: S. 864

TRANSMITTER FUNDAMENTAL	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH
7.0— 7.3		21—21.9 TV I.F.			42—44 TV I.F.		56—58.4 CHANNEL (8)	63—65.7 CHANNEL (8)	70—73 CHANNEL (1)
14.0— 14.35		42—43 TV I.F.	56—57.6 CHANNEL (2)	70—72 CHANNEL (4)	84—86.4 CHANNEL (6)	98—100.8 F-M BROADCAST			
21.0— 21.45 (TV I.F.)		63—64.35 CHANNEL (3)	84—85.8 CHANNEL (6)	105—107.25 F-M BROADCAST				189—193 CHANNELS (9) (10)	210—214.5 CHANNEL (15)
28.0— 29.7	56—59.4 CHANNEL (2)	84—89.1 CHANNEL (6)			168—178.2 CHANNEL (7)	196—207.9 CHANNELS (10) (11) (12)			
50.0— 54.0	100—108 F-M BROADCAST		200—216 CHANNELS (11) (12) (13)				450—486 500—540 POSSIBLE INTERFERENCE TO UHF CHANNELS		

FIGURE 4.—Harmonics of the amateur bands: Shown are the harmonic frequency ranges of the amateur bands between 7 and 54 MHz, with the TV channels (and TV i-f systems) which are most likely to receive interference from these harmonics. Under certain conditions amateur signals in the 1.8— and 3.5—MHz bands can cause interference as a result of direct pickup in the video systems of TV receivers which are not adequately shielded.

Re: S 864

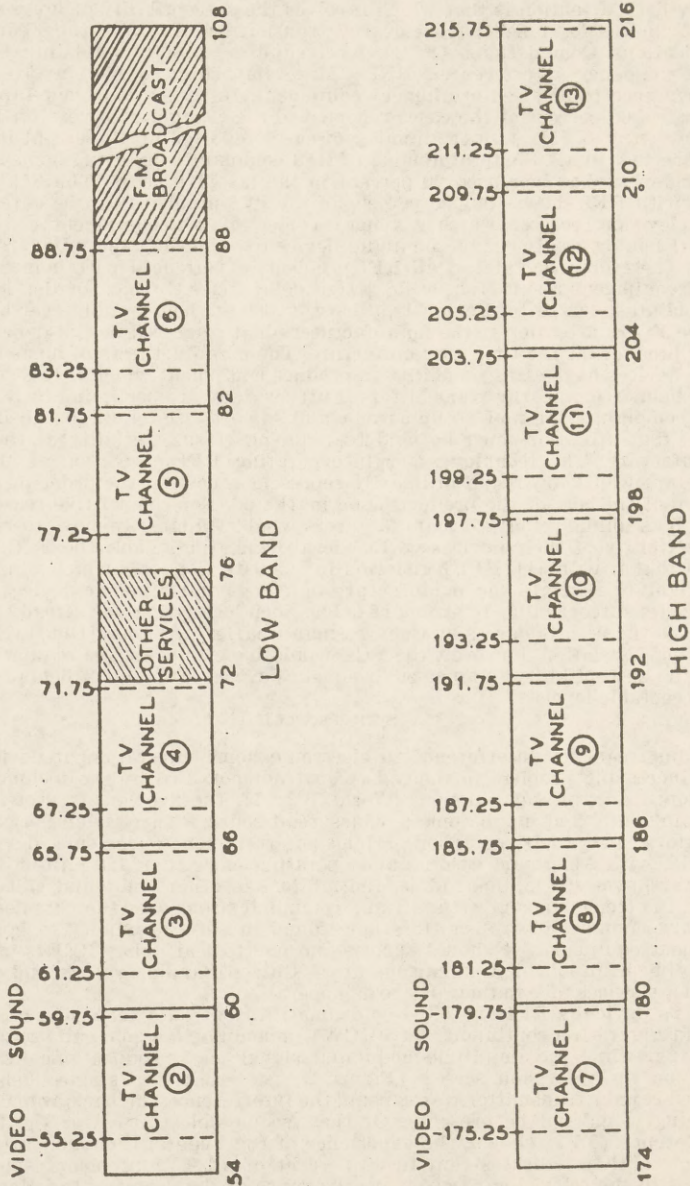


FIGURE 5.—Frequencies of the VHF TV channels: Showing the frequency ranges of TV channels 2 through 13, with the picture carrier and sound carrier frequencies also shown.

THE SUSCEPTIBILITY OF HOME-ENTERTAINMENT DEVICES TO STRONG RF FIELDS

(By Theodore J. Cohen, Secretary, RFI Task Group, American Radio Relay League, Newington, Conn.)

SUMMARY

One area of electromagnetic compatibility (EMC) which has received relatively little attention is that which involves the susceptibility of home-entertainment devices to rf fields from nearby transmitters. In 1974, the Federal Communications Commissions (FCC) received over 42,000 complaints of alleged radio-frequency interference (RFI). More important, 38,000 involved alleged interference to home-entertainment equipment. In the period from 1970 to 1974, inclusive, 60 percent of the cases reported to the Commission were for television interference (TVI), with the number of cases reported up 18 percent in the five-year period. In all, the total number of RFI complaints involving home-entertainment devices has increased 20 percent in the last five years. The FCC's experience with RFI shows that 90 percent of all TVI problems can be cured only at the television receiver. Further, when it comes to audio equipment, the only cure for RFI is by treatment of the audio device experiencing the interference. It is clear, therefore, that almost all RFI problems experienced with home-entertainment equipment result from basic design deficiencies. In fact, of the 38,000 RFI complaints referred to previously, almost 36,000 of them would never have come to the FCC's attention if the manufacturers had corrected design deficiencies in their products at the time of manufacture. The manufacturers of home-entertainment devices have a responsibility to produce equipment which is less susceptible to rf fields from nearby transmitters. Further, they are beginning to realize that RFI complaints are now so numerous, and so costly to handle on an individual basis, that attention must be paid to reducing rf susceptibility at the time of manufacture. The techniques for incorporating RFI protection at the design stage are well known, and ordinarily represent a cost on the order of a percent or two of the cost of the product being marketed. For competitive reasons, however, it is unlikely that all manufacturers would voluntarily move to reduce the susceptibility of their devices with federal legislation. Thus, the FCC has indicated that it will seek RFI legislation in the 94th Congress which would give it the right to regulate the manufacture of home-entertainment devices so as to reduce its susceptibility to strong rf fields. Such legislation has already been proposed to the 94th Congress by Congressman Charles A. Vanik (Ohio). Even with enabling legislation, however, the FCC would have to prescribe regulations such that the susceptibility to home-entertainment devices to strong rf fields is reduced to "acceptable levels".

THE PROBLEM

Radio frequency interference to electronic home-entertainment devices is an ever increasing problem in today's rf environment. Fed by the technology that developed during and following World War II, the problem is growing at an alarming rate, and has become a widespread source of irritation between radio operators and their neighbors. Home-entertainment electronic devices now abound, with Americans owning and operating more than 120 million television receivers, over 400 million radios, and millions of other audio and video devices. Given the tremendous growth in radio communications over the past decade, and the large number of transmitters now found in close proximity to home-entertainment equipment, it should surprise no one to learn that RFI is one of the most difficult problems Amateur operators, Citizen Band operators, and operators in other services face in their day to day operations.

On no device is RFI exhibited so dramatically as on a television receiver. As seen in Figure 1, a continuous-wave (CW) unmodulated signal can produce cross-hatching, while an amplitude-modulated signal may produce so-called "sound bars" on the television screen (Figure 2; note that if a single-sideband suppressed-carrier transmitter was causing the interference, the background of cross-hatching would not be present). Of the two possible causes for the television interference (TVI) shown, the experience of the Federal Communications Commission (FCC) indicates that in 90 percent of all TVI problems, spurious responses in the television receiver are the cause of the problem. It follows, therefore, that in 90 percent of all TVI cases, the problem can only be cured by treatment of the television receiver. Thus, in the majority of TVI cases, we are not concerned with interference per se, but rather, with the inadvertent interception of signals by devices which were not intended to receive radio signals. This

is unquestionably true when it comes to audio equipment (phonographs, Hi-Fi's, electronic organs, intercoms, etc.); with these devices, the only cure for RFI is by treatment of the device intercepting the rf signal. After all, there is nothing a radio operator can do to his transmitter which will stop a phonograph from acting like a short-wave receiver.

For some time, certain spokesmen for a national association of electronic manufacturing of home-entertainment equipment have asserted that less than 1 percent of the equipment in use today will ever be located near a radio station such that the equipment intended, or tuned to receive. As such, they claimed that it was unfair to burden all consumers with the additional cost of suppression circuitry since the quantity of equipment affected was thought relatively small. That only 1 percent of the equipment in use may experience alleged interference is clearly an underestimation. Today, there the circles indicate where signals are likely to be intercepted; the map shows Amateur Service Radio Service stations as 50-yard circles. Note that the contours in each case are based on legal power levels (Amateur Service, 1000 watts DC input; Citizen's Radio Service, 5 watts DC input). That RFI can be experienced well outside these zones is well known, and the areas represented by the circles are for comparison purposes only. The triangles depict fixed stations in the Land Mobile Service, although not all of them are indicated. Not shown are military radio installations, microwave relay stations, commercial repeaters, broadcast stations, are about 250,000 Amateur stations, and 2 million Citizen Radio Service stations in the United States. Most of these stations are located in the homes, and thus, are close to television receivers, radios, and audio equipment used for home entertainment.

Under these circumstances, and especially in urban and suburban areas, the FCC has estimated that 50 to 70 percent of all home-entertainment devices may be affected by strong rf fields at some time.¹ The map of a portion of Arlington, Virginia, a Washington, D.C. suburb, helps to convey a better appreciation of the burgeoning RFI problem. Prepared from FCC licensing records, experimental stations, or mobile radio stations, which number in the hundreds in this area. It is readily apparent that no electronic device in this sample area is immune to the likelihood of strong near-field radiation from a radio transmitter of some kind. Yet Arlington, Virginia, is but an example of a situation which is becoming increasingly serious in every part of our country, and indeed, the world.

TABLE 1.—RFI STATISTICS, 1970-74

	Fiscal year—					Percent increase 1970-74
	1970	1971	1972	1973	1974	
Interference to TV ¹	21,127	20,735	23,455	25,928	24,833	17.5
Interference to aural broadcasts ¹ (AM, FM).....	6,111	5,468	7,468	8,416	8,756	43.3
Interference to other services ¹	3,457	3,366	3,683	3,479	3,951	14.3
Interference to other home entertainment products (estimated) ¹	4,600	3,800	4,000	4,300	4,800	4.3
Total (all).....	35,295	33,369	38,606	42,123	42,340	20.0
Total (TV, AM, FM, and other home entertainment products).....	31,838	30,003	34,923	38,644	38,389	20.6
Total, (904, TV, AM, FM, and other home entertainment products).....	20,725	27,930	32,578	36,051	35,906	20.8

¹ Basic data from FCC annual reports for the years shown.

RFI STATISTICS

Table 1 summarizes data on RFI collected by the FCC for the period 1970 to 1974, inclusive. In 1974, the FCC received over 42,000 complaints. Of these, 38,000 involved alleged interference to home-entertainment equipment. In each of the years studied, 60 percent of the RFI cases reported to the Commission involved television receivers, with the number of cases of 18 percent in the five-year period. In all, the total number of reported RFI complaints involving home-entertainment devices has increased 21 percent in the last five years. Returning to the 1974 data, it is important to note that of the 38,000 RFI complaints referred to above, almost 36,000 of them would never have come to the FCC's attention if the manufacturers of home-entertainment equipment had corrected design deficiencies in their products at the time of manufacture.

¹ Spence, R., Address to the Washington IEEE EMC Chapter, Washington, D.C., 20 November 1974.

Finally, it should be noted that very few RFI complaints derive from operations of Amateur stations. In 1974, for example, only 400 complaints of alleged RFI were associated with Amateur operations.

THE MANUFACTURERS' RESPONSIBILITY

It is clear that almost all alleged RFI problems experienced with home-entertainment devices result from basic design deficiencies in this equipment. The few small components or filters which would prevent RFI are often left out of otherwise well-designed products as manufacturers attempt to shave costs, and hence, to reduce the prices of their products. As the number of RFI cases continues to rise, however, some manufacturers are beginning to recognize their responsibility to the consumer to provide equipment which will operate in today's rf environment. For example, a recent Consumer Products Engineering Bulletin issued by the Electronic Industries Association² states in part: "Original equipment manufacturers can no longer expect the serviceman to correct normal type interference problems in the field. The cases are becoming too frequent and the cost of correction too high to ignore this interference in the original design."

FEDERAL RFI LEGISLATION

It is a foregone conclusion that as long as the inclusion of additional components for susceptibility reduction increases a manufacturer's costs, however slightly, there will be a reluctance to take steps to improve equipment designs by the manufacturers themselves. If all manufacturers were required to install the necessary filtering components, however, none would gain a competitive edge. Thus, what now appears to be essential is reasonable federal legislation which would give the FCC the right to regulate the manufacture of electronic home-entertainment equipment, and in doing so, to protect the unknowledgeable consumer who is unable to protect himself.

The FCC has indicated that it will seek RFI legislation as part of its legislative package to the 94th Congress (1975-1977). In his comments to a recent meeting of an IEEE EMC Chapter,³ Mr. Haymond Spence, FCC's Chief Engineer, stated that while the Commission will make every effort to cooperate with manufacturers of home-entertainment devices in resolving RFI problems, the Commission would vigorously seek federal legislation which would give it the right to regulate the manufacturer of this equipment.

Consumer advocates with the 94th Congress, however, are already addressing the RFI problem. On May 15, 1975, Congressman Charles A. Vanik (Ohio) introduced H.R. 7052. This Bill would "... amend Section 302 of the Communications Act of 1934 to authorize the Federal Communications Commission to prescribe regulations with respect to certain electronic equipment that is radio frequency energy interference". The Bill was referred to the House Committee on Interstate and Foreign Commerce, and specifically to the Subcommittee on Communications (The Honorable Torbert H. Macdonald, Chairman). An early hearing on this Bill is being sought.

SUSCEPTIBILITY STANDARDS

Even with enabling legislation, the FCC would have to prescribe regulations such that the susceptibility of home-entertainment devices to strong rf field is reduced to "acceptable levels". That is, the FCC would have to prescribe susceptibility standards.

As a first step in setting RFI standards it is necessary to determine the field-strength levels encountered in typical residential areas. A great number of factors interact to determine the field strength which may be encountered in a given situation (e.g., the relative locations of the transmitting antenna and the home-entertainment device, and the effective radiated power for the transmitting station), and so, it is not possible to forecast accurately the signal levels to be encountered in every given situation. It is possible, however, to predict the range of field-strength levels likely to be encountered in the vicinity of a given transmitting installation. Once the range of expected signal levels is known, field tests can be used to verify or to modify these predictions. The measurements so obtained can then be used for the purpose of establishing susceptibility standards for home-entertainment electronic devices.

² Audio Rectification, Consumer Products Engineering Bulletin, No. 7, Electronic Industries Association (EIA). November 1974.

³ Same as 1.

TABLE II.—CALCULATED VALUES OF FIELD STRENGTH IN THE VICINITY OF RADIO TRANSMITTERS

[Field strength, db ($\mu\text{V/m}$)]

Source	Distance (meters)			
	10	20	50	100
Amateur transmitter: ¹				
180 W PEP, ant. gain: 0 db.....	139	133	125	119
1200 W PEP, ant. gains: 8 db.....	156	150	142	136
Citizens radio service transmitter: ¹				
10 W PEP, ant. gain: -2 db.....	125	119	111	105
10 W PEP, ant. gain: 0 db.....	127	121	113	107
10 W PEP, ant. gain: 8 db.....	135	129	121	115

¹ All power given as output.

Note: See reference 4 for background information.

Table II shows calculated values for field strengths which may be observed at distances between 10 and 100 meters from antennas of typical Amateur Service and Citizen Radio Service stations. All antenna gain figures are referenced to a half-wave dipole (0 db); thus, an isotropic antenna is taken to have a gain of -2.15 db. It is seen that at 10 meters distance from a Citizen Radio Service installation employing 10 watts PEP output and an isotropic antenna, the field strength is 125 db relative to 1 $\mu\text{V/m}$. This is equivalent to a field strength of 1.8 V/m. Given that interdwelling distances on the order of 10 meters are realistic for today's urban and suburban areas, it appears that 2 V/m may represent a lower acceptable limit for any susceptibility standard adopted.

With respect to an upper limit for susceptibility standards, consider the case of an amateur installation employing 1200 watts PEP output (2000 watts PEP input with the final amplifier running at 60% efficiency) and a directional antenna with 8 db gain over a dipole. For this station, the field strength 10 meters from the antenna is 156 db relative to 1 $\mu\text{V/m}$. This is equivalent to a field strength of 63 V/m, and is typical of the field strengths likely to be observed in the vicinity of amateur installations used for communications in the 14, 21, 28 and 50 MHz bands.

It should be noted that to this point all calculations, as well as the measurements cited, were made for the field surrounding an outdoor antenna. Compared with the field strength observed outside a building, the field observed inside the building will be reduced by losses in the structure. For any given building, the attenuation will depend on many factors, including the frequency employed, the number of walls in the signal path, and the type of building material employed. Normally, a structural loss of 10 to 20 db is assumed.⁵ On the other hand, it should be noted that the interference potential can be aggravated in home-entertainment equipment by the indiscriminate use of unshielded speaker and/or unshielded interequipment leads.

If we now take the previously-derived lower and upper field-strength limits, 125 and 156 db relative to 1 $\mu\text{V/m}$, respectively, and assume a structural loss of 10 db, the signal levels which may be observed within a building at a distance of 10 meters from the transmitting antenna are 0.5 and 20 V/m, respectively.

Even if the lower RFI standard referred to above is adopted, devices produced in conformance with this standard will still be susceptible to rf fields from many sources. For example, the field strength at 100 meters from a commercial broadcast station with 5 kW output and an isotropic antenna, and with the device under test located inside a building with a 10 db loss factor, is 2 V/m. Thus, a susceptibility standard in excess of 1 V/m is a necessity for electronic home-entertainment devices. It is entirely practical to incorporate this level of protection, at relatively little cost, provided that this step is taken in the design stage.

CONCLUSION

Voluntary case-by-case assistance by responsible manufacturers is only a temporary solution to RFI problems. A long-term solution requires legislation which will enable the FCC to specify and enforce RFI protection standards in the

⁴ Reference Date for Radio Engineers, Fifth Edition, pp. 25-7, 25-9, Howard W. Sams & Company, Inc., New York, 1968.

⁵ Levels of Out-of-Band Radio Frequency Electromagnetic Field Strengths in which Radio and Television Receivers may be Required to Operate, RTD Technical Memorandum No. 1 10, Directorate of Radio Technology Ministry of Posts and Telecommunications, England.

manufacture of home-entertainment devices—legislation similar to that proposed by Congressman Vanik in H.R. 7052. It will be necessary for the Commission to establish reasonable susceptibility standards for this purpose.

RFI AS IT CONCERNS THE RADIO OPERATOR, THE CONSUMER AND THE MANUFACTURER OF THE HOME-ENTERTAINMENT EQUIPMENT

(Theodore J. Cohen, Secretary, RFI Task Group, American Radio Relay League, Newington, Conn.)

SUMMARY

In Fiscal 1975, the Federal Communications Commission (FCC) received 55,289 complaints of alleged radio-frequency interference (RFI), a 30% increase over the number of cases reported in Fiscal 1974. Of the complaints received, 45,002 involved electronic home-entertainment equipment, and 82% of these were attributed to design deficiencies in the equipment, and not to the transmitters involved. That relatively few cases of RFI are attributable to radio transmitters indicates the effectiveness with which harmonic radiation has been suppressed in transmitters built today. In this regard Amateur Radio operators, and manufacturers of transmitters used by Amateurs, have long sought to reduce the harmonic content of transmitted signals by using techniques which, for example, reduce the amplitude of harmonics generated in the transmitter, and prevent harmonics from being fed to the antenna. Then too, in cases where an RFI problem must be corrected at the device intercepting the rf signal, Amateurs have a long history of providing the consumer with the free parts and service required to resolve the problem. For these reasons, RFI complaints related to the operation of stations in the Amateur Service only amount to about 4-7% of the cases reported which involve home-entertainment devices. In the case of stations operating on frequencies assigned to the Citizens Radio Service (CRS), however, RFI problems related to electronic home-entertainment devices are increasing rapidly, and now account for almost 80% of the cases reported. This is due not only to the exploding population of CRS licensees (now increasing at better than 6 million per year, almost all of whom lack the technical background with which to cope with RFI), but also to the increased use of solid-state components in home-entertainment devices, and to the proliferation of these devices and CRS stations in urban and suburban areas. Manufacturers of CRS transmitters have an obligation to reduce harmonic radiation from their equipment. An even greater obligation, however, rests with the manufacturers of home-entertainment equipment, for most RFI cases must still be resolved at the device experiencing the interference. Tests performed at the ARRL Laboratory suggest that if even minimal precautions are taken by manufacturers to reduce the susceptibility of their products to rf signals (for example, through the inclusion of an inexpensive high-pass filter in the tuner of a television receiver), the incidence of RFI could be significantly reduced. While some manufacturers now incorporate the necessary susceptibility-reducing components in their equipment, many still do not assist the consumer in correcting RFI problems by providing the parts and service required. Should the electronics industry fail to take those steps necessary to resolve the RFI problem, however, Federal legislation similar to that embodied in H.R. 7052 remains as but one means by which the FCC could insure that the non-technical Public is offered electronic home-entertainment equipment capable of operating properly in today's rf environment.

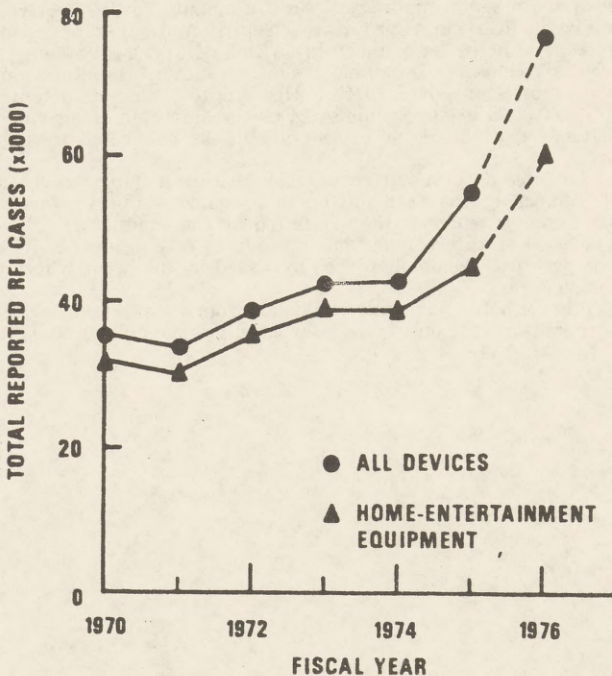
THE RFI PROBLEM

The problem of alleged radio-frequency interference (RFI) to electronic home-entertainment equipment is growing at an unprecedented rate. Today, a myriad of stations licensed in the Citizens Radio, Amateur, Land Mobile, and Broadcast Services, among others, are located in close proximity to homes and apartments, and are radiating signals which can, and often do, affect the operation of television receivers, radios, and other audio and video devices used by consumers.

In Fiscal 1974 the Federal Communications Commission (FCC) received 42,340 RFI complaints, a 20% increase over the number of complaints received in 1970 (Figure 1). In Fiscal 1975, however, RFI complaints jumped to 55,289, 30% higher than the number of cases reported in 1974. Of the complaints received in

1975, 45,002 involved electronic home-entertainment devices. More important, 82% of the 45,002 cases were attributed by the Commission to design deficiencies in this equipment and not to the transmitters involved. Thus, in the majority of cases, we are not concerned with interference *per se*, but rather, with the inadvertent interception of signals by devices which were not intended to receive radio signals.

The growth of RFI problems is expected to accelerate during Fiscal 1976. Based on data acquired during the first half of this year, and on monthly trends observed in the receipt of RFI complaints over the past six years, the Commission has forecast that it will receive about 77,000 complaints during the fiscal year. This would represent a 39% increase over the number of complaints received in 1975. As in the past, the majority of the complaints will involve design deficiencies in electronic home-entertainment equipment.



TELEVISION INTERFERENCE (TVI)

Since 1970, roughly 60% of all RFI complaints received by the FCC have involved television receivers. However, the Commission's experience indicates that in 90% of all TVI problems, spurious responses in the television receiver produce the interference. That relatively few cases of TVI are attributable to radio transmitters indicates the effectiveness with which harmonic radiation has been suppressed in transmitters built today.

SUPPRESSION OF HARMONIC RADIATION

Amateur Radio operators, and manufacturers of transmitters used by Amateurs, have long sought to reduce the harmonic content of transmitted signals by using techniques which reduce the amplitude of harmonics generated in the transmitter, which prevent stray radiation from the transmitter and associated wiring, and which prevent harmonics from being fed to the antenna.

Harmonic energy in transmitters may be reduced by a variety of techniques. It may be diminished, for example, by employing link coupling between the driver and amplifier stages of a transmitter. Link coupling reduces the coupling between the driver and the amplifier at harmonic frequencies, and prevents driver harmonics from being amplified. Then too, VHF resonance points in power amplifier tank circuits may be found using a grid-dip meter. If such resonances

are found near a TV channel, changing some circuit components by small values will move the resonance to a less-troublesome frequency.

Another technique for reducing harmonic radiation takes cognizance of the fact that operating conditions (grid bias and grid current) affect the harmonic content of signals. If radiation at one harmonic frequency is particularly disturbing, a change in the operating conditions can minimize radiation at that frequency. However, it should be noted that in changing the operating conditions to minimize one harmonic, other harmonics may be enhanced.

Finally, the use of harmonic trap in the plate lead of the power amplifier stage is quite useful in those cases where only a single TV channel is affected. The trap represents a high impedance at the harmonic frequency, and as such, the harmonic current flowing through the tank circuit is reduced.

With reference to techniques which prevent stray radiation from leaving the transmitter and its associated wiring, the most effective method involves effective shielding and proper grounding of the equipment. To be effective, shielding must completely enclose the appropriate circuits, and must have no openings (such as louvers, and holes for connectors) which will permit rf energy to escape. Where different portions of the shield come in contact, all joints must exhibit good electrical connections over their entire length. Further, attention should be given to the material used for shielding, as the shielding effect varies directly with conductivity. The shield, of course, should be connected to a good earth ground.

Lead treatment also deserves attention. Conductors leaving the shield (for example, leads connecting the transmitter to its power supply) form paths for the escape of rf energy which is then radiated by the conductors. Thus, shielded wire should be used to interconnect various pieces of equipment. Where this is not possible or practical, leads should be bypassed at the point where they leave the shielded enclosure.

The last step in reducing harmonic radiation from a given transmitter installation requires that harmonic energy be prevented from reaching the antenna.

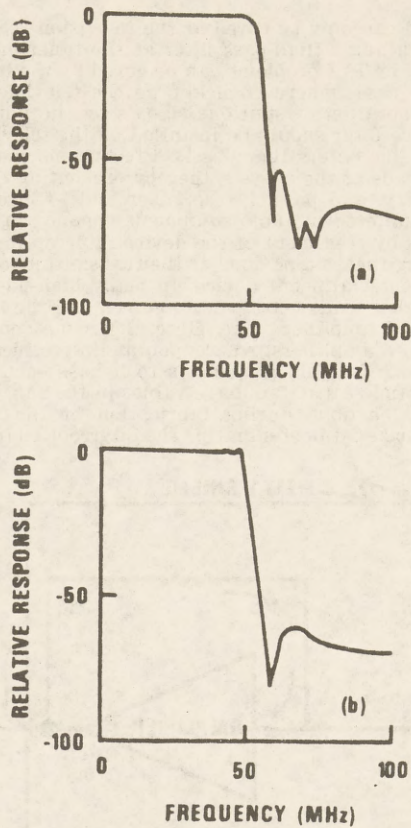


FIGURE 2.—Spectral response curves for lowpass filters used by operators in the Amateur Service: (a) Drake 1-kw filter; (b) Johnson 1-kw filter (Rasmussen and Gerue¹).

Perhaps the most effective method for reducing harmonic radiation is to install a low-pass filter in the coaxial feed line, at the transmitter. This filter will pass energy at the fundamental frequency with little appreciable loss, while energy at frequencies above the filter's cutoff frequency will be significantly attenuated (Figure 2).

Another technique used by Amateurs to reduce the harmonic content of signals fed to the antenna involves the use of an antenna coupler which exhibits high selectivity. Using this technique, 20 to 30 dB reduction of the second harmonic, and greater reduction of higher-order harmonics, is possible.

THE INTERCEPTION OF SIGNALS BY HOME-ENTERTAINMENT EQUIPMENT

Regardless of the precautions taken to reduce harmonic radiation, many devices built today are still highly susceptible to rf fields at fundamental frequencies from nearby transmitter installations. Television receivers, for example, frequently suffer fundamental, or front-end, overload. Here, the fundamental signal from the radio transmitter is so strong that it overloads the television receiver's tuner circuitry, thereby causing the tuner to produce spurious harmonic signals which interfere with the reception of the desired television station. The problem

¹ Rasmussen, D.C., and D. R. Gerue, "Harmonic TVI, A New Look at an Old Problem", *QST*, September, 1975.

of front-end overload can only be cured at the television receiver, and is usually accomplished by installing a high-pass filter at the tuner-input terminals.

While the majority of TVI problems can be cured by the installation of a high-pass filter, there are cases where rf pickup on the television receiver's AC line can result in the generation of spurious signals by the unit's power supply. If this occurs, an AC-line filter should be installed on the television receiver, at the point where the AC line enters the chassis. Precautions should also be taken to bypass the speaker leads at the chassis, thereby preventing rf energy from reaching the audio circuitry, and possibly the tuner and i-f circuitry as well.

When RFI is encountered in audio equipment (phonographs, hi-fi's, intercoms, etc.) the only cure is by treatment of the device intercepting the rf signal. Obviously, there is nothing that can be done at the transmitter to eliminate audio rectification in a home-entertainment device. In many high-fidelity systems, for example, extended speaker leads act as an antennae, and the rf picked up by these leads is fed to the final amplifier stage. Here, the rf may enter the feedback circuit found in most hi-fi amplifiers, whereupon audio rectification occurs (Figure 3). One suggested cure for this problem is to bypass each speaker lead to the chassis with disc-ceramic capacitors have values in the range 0.001–0.02 μF . This can most effectively be done during fabrication of the equipment. Shielded speaker leads will also assist in eliminating the interception of rf energy.

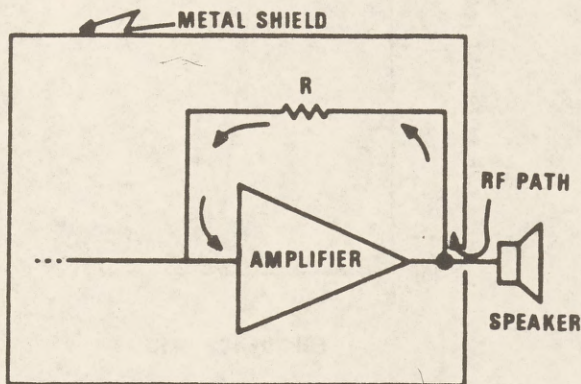


FIGURE 3.—Unwanted rf energy in the feedback loop of hi-fi amplifiers, which is picked up by the speaker leads, is the cause of most RFI experienced with these devices (McCoy).

In the case of phonographs, rf energy is often picked up by leads in the tone arm, and is rectified in the first audio amplifier stage. Such a case is shown in Figure 4, where the first stage employs a high-impedance Darlington-pair circuit. The "cure", as shown by dashed-line components, involves by-passing the pickup-head leads, and the base and emitter leads in the Darlington pair with 0.001 μF disc-ceramic capacitors.

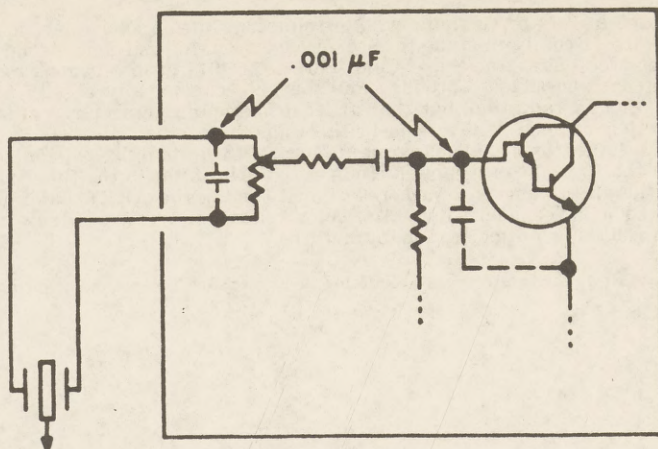


FIGURE 4.—Suggested placement of by-pass capacitor in a phonograph.

Additional information for eliminating RFI in audio devices, including such equipment as P-A systems and electronic organs, can be found in McCoy² and in *The Radio Amateur's Handbook*.³

By virtue of their technical knowledge and their sense of responsibility to the Public, operators in the Amateur Service have a long history of providing the consumer with the free parts and service required to resolve RFI problems. For these reasons, complaints of RFI to home-entertainment equipment which are related to Amateur activities only amount to about 4 to 7% of the cases reported.

In the case of stations operating on frequencies assigned to the Citizens Radio Service (CRS), however, RFI problems related to electronic home-entertainment devices are increasing rapidly. While 69% of the RFI complaints reported to the FCC in Fiscal 1975 were related to the operation of CRS stations, data for the first half of Fiscal 1976 indicates that stations operating on frequencies assigned to this Service are now associated with 80% of the complaints received. This is due not only to the exploding population of CRS licensees (presently increasing at better than 6 million per year, almost all of whom lack the technical background with which to cope with RFI), but also to the increased use of solid-state components in home-entertainment devices, and to the proliferation of these devices and CRS stations in urban and suburban areas.

There is little question that most of the RFI complaints related to activities of CRS stations result from design deficiencies in electronic home-entertainment products. Regardless, manufacturers of CRS transmitters have an obligation to reduce harmonic radiation from their equipment. An even greater obligation, however, rests with the manufacturers of home-entertainment equipment, for most RFI cases must still be resolved at the device experiencing the interference.

REDUCED RFI SUSCEPTIBILITY THROUGH RESPONSIBLE DESIGN

It has long been the contention of the FCC and the ARRL that if even minimal precautions were taken by manufacturers to reduce the susceptibility of their products to rf signals, the incidence of RFI could be significantly reduced. This is especially true with regard to television receivers, for as noted above, while TVI cases account for 60% of all complaints involving home-entertainment equipment, 90% of these cases result from design deficiencies in the receiver.

The inclusion of a high-pass filter in a television receiver's tuner stage at the time of manufacture is one of the most effective methods for reducing rf susceptibility in the receiver. Most manufacturers recognize this fact, but some, apparently, still feel that to incorporate a filter in the tuner during fabrication would place their equipment at a competitive disadvantage. That this is not true was

² McCoy, L., "RFI", *QST*, July, 1972.

³ *The Radio Amateur's Handbook* (Robert Myers, Editor), American Radio Relay League, Newington, Conn., 1976.

demonstrated in 1974 by Grundig, who introduced a line of color television receivers which are virtually immune to interference from high rf fields.⁴ The production of these receivers—the Super-Color-Series for 1974–1975—demonstrated that it was not only possible to produce and market economically a set which will reject out-of-band radiation, but that at least one manufacturer recognized that the production of such receivers is in the Public's interest.

There are indications that many manufacturers who build television receivers for sale in the United States now include a high-pass filter in the tuner stage. To ascertain the effectiveness of such redesigned tuners, the ARRL Laboratory recently tested a late-model, solid-state, color television receiver which was produced by a well-known American manufacturer.

⁴ Koch, E., "Now, An Interference-Free Color Television Set", Funkschau, Spring, 1974.

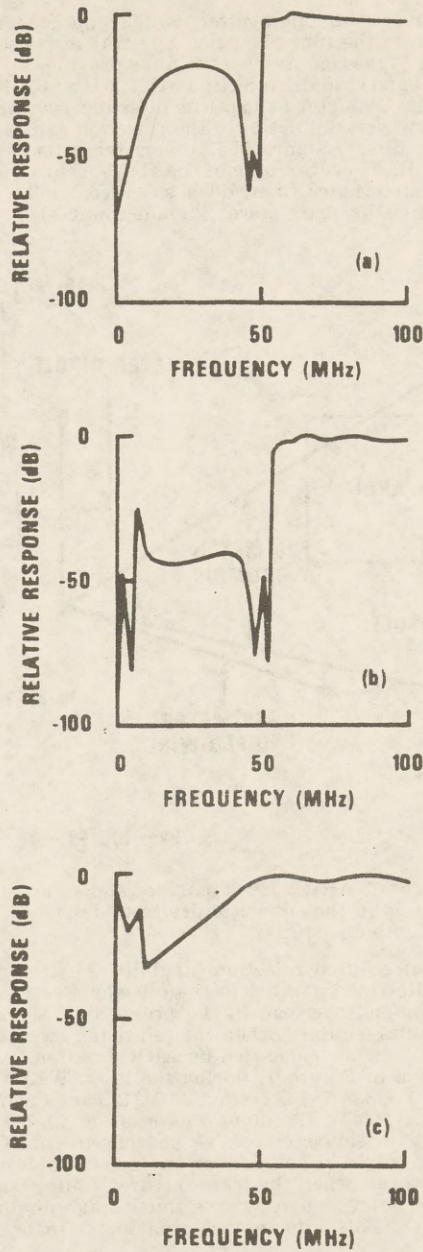


FIGURE 5.—Spectral response curves for high-pass filters: (a) filter incorporated in tuner of American-made, solid-state, color television received; (b) Drake TV-300-HP filter; (c) inexpensive filter available at drug stores and discount electronic parts houses.

The television receiver's high-pass filter, which appeared to be of the m-derived type, was built into the tuner housing. Spectral response characteristics of the filter are shown in Figure 5a. As seen the filter provides about 25 dB rejection at 14 MHz (20 Meter band), 20 dB rejection at 21 MHz (15 Meter band), and 18 dB rejection at 28 MHz (10 Meter band). The filter incorporated in the television receiver under test, however, did not have the rejection capabilities of the Drake TV-300-HP high-pass filter (Figure 5b), the latter attenuating signals up to 52 MHz by roughly 40 dB. However, both of the above-mentioned filters had better spectral response characteristics than did a so-called "noise" or "interference" filter which is marketed by drug stores and discount electronic parts houses (Figure 5c).

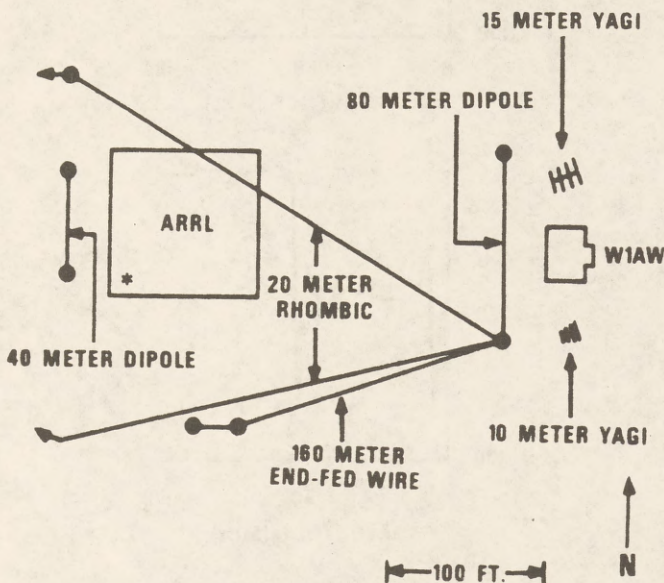


FIGURE 6.—A Plan view of ARRL Headquarters and radio station W1AW. The television receiver used in the susceptibility tests described herein was located at the point marked with an asterisk (*).

Despite its somewhat reduced rejection capabilities as compared to the Drake high-pass filter, the filter incorporated in the television receiver was quite effective in preventing front-end overload in the presence of strong rf signals. This can be seen in the results obtained when the television receiver was operated in the presence of strong rf fields generated by ARRL station W1AW (a plan view of the test site is shown in Figure 6; during the tests, W1AW was transmitting simultaneously in the 1.8, 3.5, 7, 14, 21, and 28 MHz bands using 1 KW DC input on the above 3.5 MHz (100 W DC input was used on 1.8 MHz) and A1 (CW) emission). With the television receiver, as purchased, tuned to Channel 3 (60 to 66MHz), and using only a simple indoor antenna ("rabbit ears"), no sign of TVI was present. However, when the manufacturer's filter was removed, fundamental overload of the television receiver's tuner stage produced significant interference (Figure 7a). This interference was found to be related to the 1.8 MHz signal.

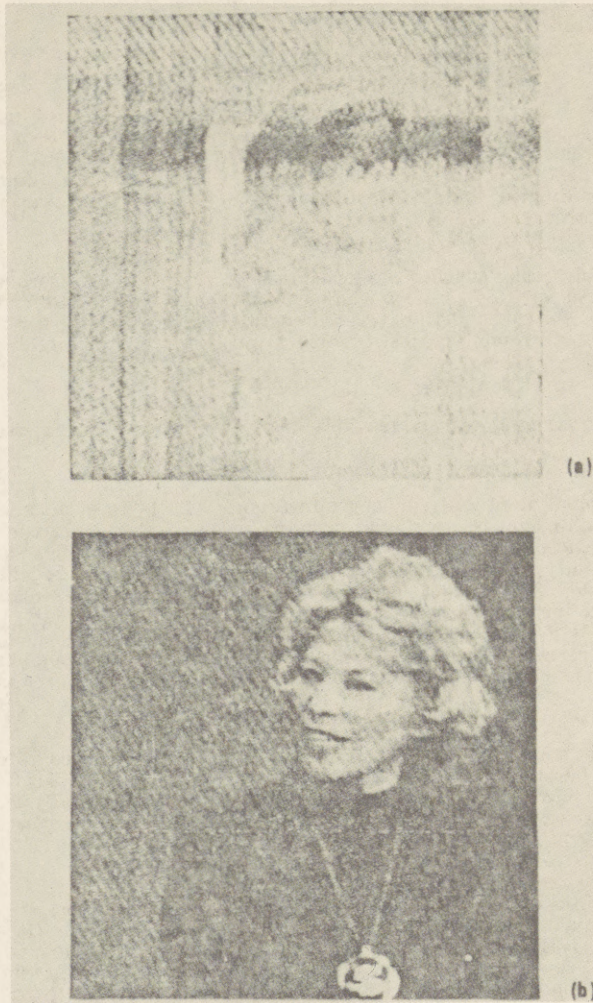


FIGURE 7.—Television interference related to the operation of W1AW's 100 W, 160 meter transmitter: (a) with no high-pass filter on the receiver; (b) with a Drake TV-300-HP filter connected outside the receiver, at the antenna terminals.

With the Drake TV-300-HP filter connected *outside* the television receiver at the antenna-input terminals, and with the manufacturer's filter removed, interference is significantly reduced, though not entirely eliminated (Figure 7b). Thus, even though the Drake high-pass filter had better band-rejection characteristics, its effectiveness was negotiated, to some extent, by mounting its outside the television receiver's cabinet, at the antenna terminals.

The inescapable conclusion to be drawn from these tests is that even a mediocre high-pass filter, when incorporated in the television receiver's tuner *at the time of manufacture*, can remove most, if not all, out-of-band high-frequency radiation which might otherwise cause TVI.

CONCLUSION

While some manufacturers of electronic home-entertainment equipment now incorporate the necessary susceptibility-reducing components in their equipment, many still do not assist the consumer in correcting RFI problems by providing needed advice, parts and service. Should the electronics industry fail to take those steps necessary to resolve RFI problems, however, Federal legislation similar to that embodied in H.R. 7052 (94th Congress) remains as but one means by which the FCC could insure that the nontechnical Public is offered electronic home-entertainment equipment which is capable of operating properly in today's rf environment.

ACKNOWLEDGEMENT

I gratefully acknowledge the assistance of Mr. Anthony Dorbuck, Assistant Technical Editor, *QST*, ARRL, who performed the cited laboratory tests at Newington, Connecticut, and who, together with Mr. Victor C. Clark, Vice President, ARRL, offered valuable suggestions which were used to improve this presentation.

 RADIO FREQUENCY INTERFERENCE—WHAT IT IS * * * AND WHAT TO DO ABOUT IT

(By Dr. Theodore J. Cohen, KFD-2459)

The problem of radio-frequency interference (RFI) to electronic home-entertainment equipment is growing at an unprecedented rate. Today, tens of millions of stations licensed in the Citizen's Radio and Amateur services are located in close proximity to homes and apartments, and are radiating signals which can, and often do, affect the operation of television receivers, radios, and other electronic home-entertainment devices.

What is RFI, and how large a problem is it? Further, why should CB operators be concerned with RFI, and what can be done when a neighbor experiences this problem? These are but a few of the questions to be answered in this article.

WHAT IS RFI?

The term "radio frequency interference," or "RFI," is used to describe that situation wherein a radio signal allegedly interferes with the operation of another electronic device. Thus, if a neighbor's television receiver displays cross-hatching or sound bars when you are on the air (so-called television interference, or TVI), the receiver is said to suffer from radio frequency interference (see Figures 1 and 2). But wait a minute . . . all radio frequency interference is not the fault of the radio transmitter! It is true that in some cases, the cross-hatching and sound bars are caused by harmonic radiation in the TV channel to which the receiver is tuned. However, if a legitimately radiated signal is so strong at the television receiver as to cause the receiver to generate spurious signals within the tuner, cross-hatching and sound bars can also result. In the latter case, then, we are not concerned with interference, but rather, with the inadvertent interception of signals by devices which were not intended to receive the radio signals.

With regard to audio devices such as phonographs, electronic organs, etc., there is no such thing as radio frequency interference . . . only radio frequency interception. After all, audio devices should not act as radio receivers. That they inadvertently intercept and process signals they were not intended to receive as the result of design deficiencies in these devices. As such, the only cure for an audio device which experiences alleged RFI is by treatment of the device which is intercepting the radio signals.

HOW BIG A PROBLEM IS RFI?

In 1953, RFI complaints forwarded to the Federal Communications Commission (FCC) numbered about 21,000 per year, and were climbing at a relatively moderate pace. Then, late in the 1960's, three events occurred which would lead to a virtual explosion in the incidence of RFI:

1. Rapid growth in 27 MHz CB radio;
2. Increased use of solid-state devices in home-entertainment equipment;
3. Increased use of electronic entertainment equipment in the home.

By the end of September 1977, the number of RFI complaints forwarded to the FCC exceeded 110,000 per year. And the Commission now expects to receive almost 200,000 RFI complaints per year by the end of this decade (see Figure 3).

Given the popularity of television, it should come as no surprise to learn that almost 90 percent of all interference cases reported to the FCC involve impaired television reception. Further, with the number of licensed CBers in the U.S. now over 20 million, it is not unexpected that 85 percent of all TVI cases are associated with CB radio transmissions.

The growth in RFI problems has affected the communicator as much as it has the general public. Today, according to the Personal Communications Foundation,¹ "Municipalities and homeowners' associations throughout the country are acting to eliminate the erection and maintenance of amateur and CB towers and antennas." In many areas, CB operators are even being sued for "disturbing the peace" or for creating a "public nuisance;" these suits are brought to court by neighbors who experience RFI problems. Clearly, something must be done to reduce the incidence of RFI before the use of CB radio is severely curtailed by local, state and federal regulations.

CAN RFI BE CURED

In almost all cases, RFI can be cured. However, what one does to resolve a particular case of interference or inadvertent interception necessarily depends on the type of problem experienced and on the equipment involved.

As an example, consider interference to television receivers which are attributable to inadequate suppression of transmitter harmonics. A recent FCC study showed that almost 55 percent of all CB-related TVI complaints resulted from such harmonics, and so, the subject is far from academic.

While some harmonic radiation can emanate from "rf leaks" in the shielding around a CB transmitter, most is radiated with the intended 27 MHz signal via the system antenna. In such cases, the best cure for this problem is to install a low-pass filter in the coaxial feedline at the transmitter. Such a filter will suppress energy above 50 MHz (this frequency is just below the first television channel, Channel 2), but will pass energy at lower frequencies; hence the name "low-pass filter."

Several types of low-pass filters are on the market today, and most will adequately suppress harmonics encountered with CB transmitters. To be on the safe side, however, take a moment and examine the filter and the manufacturer's specifications. A good filter should be well shielded and should have a negligible insertion loss at frequencies up to about 50 MHz; above this frequency, attenuation should be in excess of 50 dB (that is, at frequencies above 50 MHz, the filter should reduce the power reaching the antenna by a factor of 100,000). Further, there is no need to buy a filter capable of handling power levels of 1 kW when legitimately-used CB transmitters operate at considerably lower power levels.

In about 45 percent of all CB-related TVI cases, FCC studies have shown that the interference is actually generated by the television receiver itself. What happens here is that a strong 27 MHz signal overloads the amplifier in the television receiver's tuner, causing the TV tuner to produce spurious harmonic signals which interfere with television reception. Such "fundamental," or "front-end" overload, as it is often called, is usually cured by installing a high-pass filter at the antenna input terminals of the television receiver.² In fact, experience has shown that high-pass filters are effective in eliminating or significantly reducing TVI in 80 percent of all cases when front-end overload is a problem.

Since front-end overload of a television receiver is caused by excessive 27 MHz energy in the tuner, another way of reducing the signal level at the tuner is to separate the CB and television antennas to the maximum extent possible.

Finally, as noted earlier, the only way to cure a case of RFI which is encountered in an audio device is by treatment of the device which is intercepting

¹ The Personal Communications Foundation is a non-profit, tax-exempt California corporation which has been organized expressly for the purpose of creating a comprehensive personal communications law library. For more information on the Foundations, write: Personal Communications Foundation, 10960 Wilshire Boulevard, Suite 1504, Los Angeles, Calif. 90024.

² To be most effective, a high-pass filter should be installed inside the television receiver, at the antenna-input terminals for the tuner. However, such an installation requires disassembly and modification of the television receiver, something which should only be attempted by those who are experienced in the field of electronics.

the rf signal. In many high-fidelity systems, for example, rf is picked up by extended speaker leaders (antennas!) and is fed to the final audio amplifier stage (Figure 4). Here, the rf enters the feedback circuit, whereupon audio rectification occurs and the radio operator's voice is heard. In some cases, the audio amplifier does not even have to be operating for voices to be heard!

To cure this type of RFI problem, technicians often bypass each speaker lead to the amplifier chassis using suitable disc-ceramic capacitors. The installation of shielded speaker leads is also found to assist in eliminating RFI in high-fidelity systems.

WHO IS RESPONSIBLE FOR CORRECTING RFI PROBLEMS?

If the problem is one which results from harmonic radiation, the CB operator, of course, must take those steps necessary to suppress such radiation at his transmitter.

On the other hand, if the problem is due to front-end overload of a television receiver's tuner, or if an audio device is involved, one can say, at the least, that the responsibility for curing the problem does not rest with the CBer. Further, there are several reasons why CB operators should not even attempt to correct such RFI problems:

1. In the case of front-end overload, or when an audio device is involved, the problem is due to a design deficiency in the device which is experiencing the interference. As such, the manufacturer of the device—not the consumer or the radio operator is responsible for correcting the problem.

2. Few CB operators are electronic technicians. Thus, few are capable of making the circuit modifications necessary to correct RFI problems with electronic home-entertainment devices.

3. Modifying the circuitry of an electronic device, and, in some cases, even opening the cabinet, will void the manufacturer's warranty.

4. You may be on good terms with your neighbors, but if you modify a piece of their equipment, and if the modified device fails (as it eventually will), guess who will be blamed?

In short, it is not a good idea to work on a neighbor's electronic home-entertainment devices when RFI problems are experienced; instead, turn to the manufacturer.

THE MANUFACTURER? HOW CAN HE HELP?

It should be clear by now that a significant percentage of all RFI problems experienced with home-entertainment devices result from basic design deficiencies in these devices. Such deficiencies occur in otherwise well-designed products because manufacturers attempt to shave costs—and hence, to reduce prices—by eliminating from their designs those few small components or filters which would prevent RFI. As the number of RFI cases continues to rise, however, many manufacturers have come to recognize that they have a responsibility to the consumer to provide equipment which will operate in today's rf environment. In some cases, manufacturers will provide advice, parts, and even the service required to resolve RFI problems which involve their products.

WHICH MANUFACTURERS WILL COOPERATE IN RESOLVING RFI COMPLAINTS?

Policies regarding the correction of RFI problems vary from manufacturer to manufacturer. Thus, to assist radio operators and consumers in resolving RFI problems, the RFI Task Group of the American Radio Relay League (ARRL) has prepared a comprehensive list which reviews the RFI policies of major manufacturers, and which gives the points of contact within each company to whom complaints should be forwarded. A typical listing would appear as follows:

XYZ Systems,
Community Parkway,
Everytown, Everystate 999,
(999) 111-0000
J. B. Good,
General Manager.

RFI problems involving both television and audio products may be referred to J. B. Good.

Requests for high-pass filters should include model number and serial number of the XYZ television receiver. Filter installation is the customer's responsibility.

The ARRL RFI Assistance List is considered by many radio operators to be the most useful document available for obtaining assistance on RFI problems. Then too, many operators (and their neighbors) consult this list prior to purchasing electronic home-entertainment products so as to determine which manufacturers will cooperate in resolving RFI problems in the event such problems are encountered.

To secure a copy of the RFI Assistance List simply send a stamped (15 cents), self-addressed, business-size envelope to: RFI Assistance List, American Radio Relay League, 225 Main Street, Newington, Conn. 06111.

Alternatively, it should be known that the ARRL RFI Assistance List is included as an appendix to a new bulletin on RFI which has been prepared by the Federal Communications Commission. Entitled "How to Identify & Resolve Radio-TV Interference Problems," this bulletin covers all aspects of the RFI problem, and includes material on identifying interference to television receivers, on home remedies for television interference, on identification of audio interference, on radio transmitter operator guidelines, and on other related topics. For a copy of this colorful, 30-page bulletin, send a check or a money order for \$1.50 to: Consumer Information Center, Dept. 051F, Pueblo, Colo. 81009. Request the bulletin by name.

It should be noted that copies of the FCC bulletin are provided free to those individuals who file an RFI complaint with the Commission. If you wish to file a complaint, send it to: Federal Communications Commission, 2025 M Street, NW., Washington, D.C. 20554.

As a final note, when using the ARRL RFI Assistance List in an attempt to resolve an RFI problem, provide the manufacturer with the information he needs in a clear, concise, and courteous manner. Remember, the manufacturer is under no obligation to provide advice, parts, or service. That he chooses to cooperate in resolving RFI complaints is done of "god will," and is, therefore, to be appreciated.

SUMMARY

This article has reviewed the subject of radio frequency interference (RFI). As was seen, interference to television receivers which is caused by harmonic radiation from a CB transmitter can generally be resolved by installing a low-pass filter in the coaxial line at the transmitter. In those cases where fundamental overload (front-end overload) of a television tuner occurs, or when an audio device is involved, the problem must be cured at the device which is inadvertently intercepting and processing the rf signal. To this end, it is suggested that the radio operator not attempt to resolve such RFI problems by modifying the device which is experiencing interference; rather, it is recommended that the manufacturer of the device should be contacted, and should be requested to provide assistance in the form of advice, parts, and (possibly) service. A list of manufacturers who will assist in resolving RFI complaints is available from the ARRL or from the U.S. Government. If used in a responsible manner, the material provided in this list can significantly reduce the time and effort required to correct RFI problems.

By 1979, the FCC estimates that as many as 9,000,000 individuals (almost 3 million households) will experience CB-related RFI. Thus, it behooves all of the parties concerned—the CB operator, the consumer, and the manufacturers of electronic home-entertainment—work together in resolving RFI cases. Only in this way will it be possible to resolve one of the greatest problems facing the CB service today.

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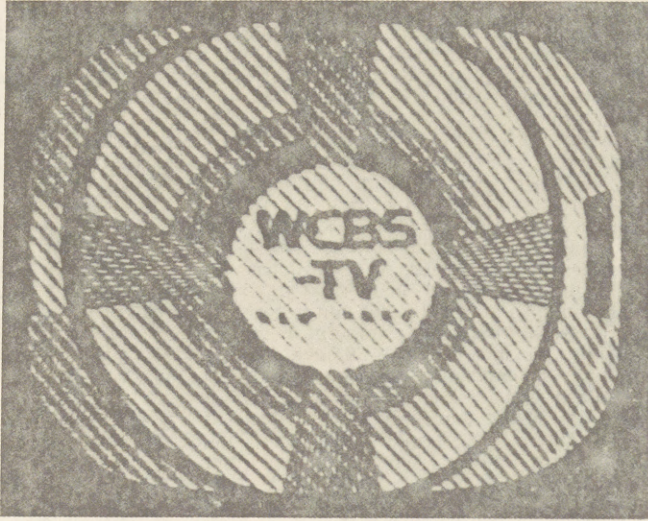


FIGURE 1.—Television interference from an unmodulated signal. The cross-hatching may be caused by (1) Harmonic radiation in the TV channel to which the receiver is tuned, originating in a nearby radio transmitter; (2) Spurious responses, in the television receiver itself, to a signal legitimately radiated by a nearby transmitter.

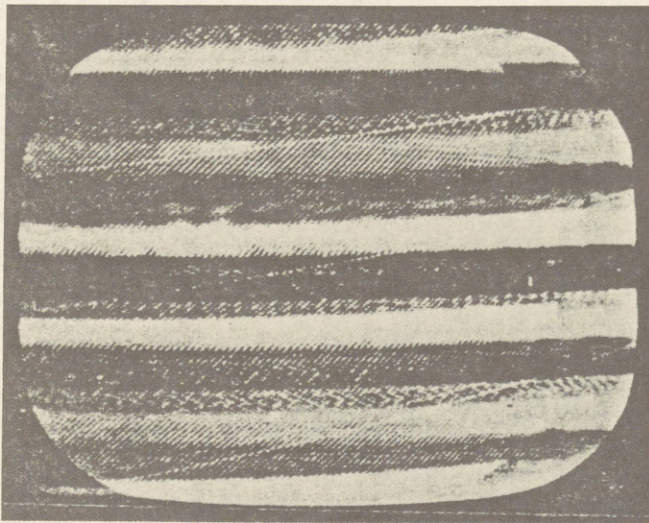


FIGURE 2.—Television interference from an amplitude-modulated signal such as those used in the CB service. The causes of the intermittent horizontal bars superimposed on a background of cross-hatching are the same as for plain cross-hatching as described in Figure 1.

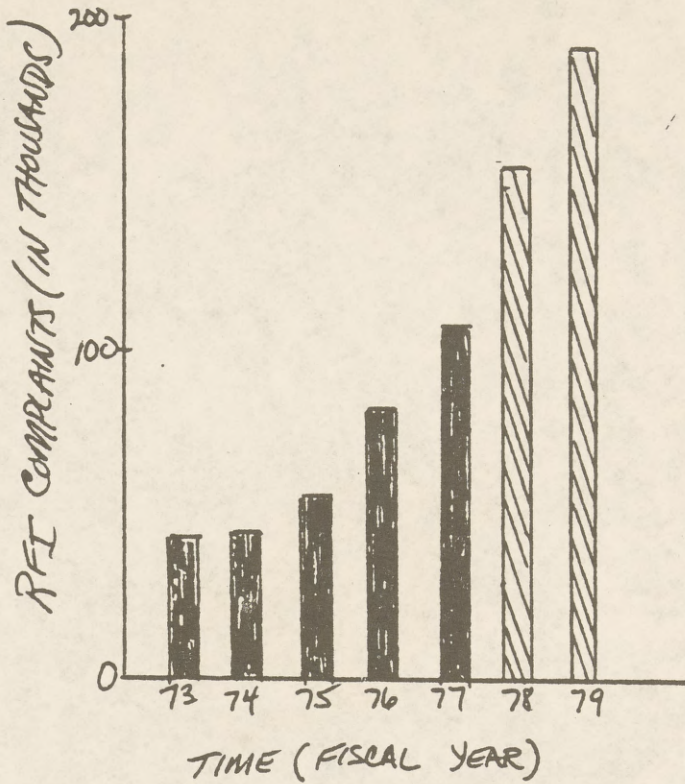


FIGURE 3.—The number of RFI complaints forwarded to the Commission expected to reach 200,000 per year by 1979 (1978 and 1979 data are estimate)

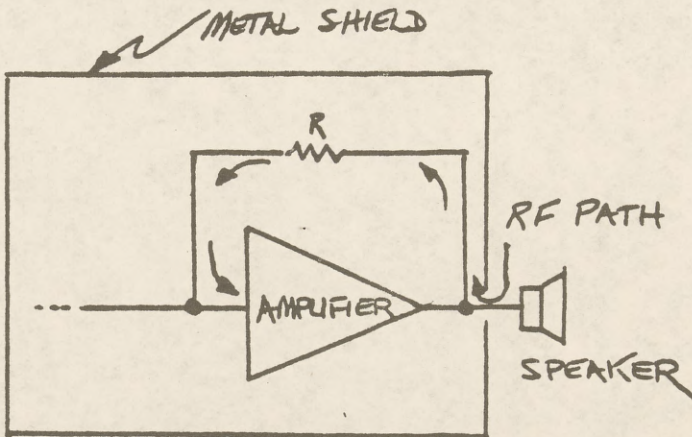


FIGURE 4.—Unwanted energy in the feedback loop of hi-fi amplifiers, which is picked up by the speaker leads, is the cause of most RFI experienced with these devices.

