

be committed through the use of general purpose computers. If, on the other hand, the definitions are too loose, then computer users with no interest in audio may be penalized.

My interpretation of the bill's definitions of digital audio interface device, digital audio recording device, digital audio recording medium is that they are overly loose and can be interpreted to apply to general purpose computing subsystems that may or may not be used for audio recording. I think the Senate rewording helps a bit, but, in my opinion, it is not enough to prevent this from occurring.

Finally, the subcommittee should be aware of some possible future developments germane to intellectual property rights. The bill recognizes that piracy can occur both from storage media and from broadcast. Today, the latter is no threat since there is no digital broadcasting, and even the best FM broadcasting gives lower quality than a record. But people are now experimenting with digital audio broadcasting and in all probability it will be distributed commercially in not too many years.

The World Administrative Radio Conference now underway in Spain is considering requests for a frequency allocation for this service. Over-the-air digital broadcasting will always be limited by bandwidth constraints, but, later on, huge capacities will be available with door-to-door optical cable constituting, in effect, an online information marketplace, and this has some relevance to the other subcommittee of this full committee that is now meeting on the subject of the Baby Bells handling information services.

Subscribers will be able to make a selection of a variety of information sources, including audio or video which will be delivered to the home information center almost instantly as a stream of digits. The home information center will be general purpose, including the ability to store audio, video and textual information.

It is not inconceivable that some day this will be the primary way in which people obtain their records—maybe 10 or 15 years from now. If everything ever recorded is available in this way at a reasonable price, then why own records or tapes at all. In this situation piracy will consist of storing audio and video and then distributing it on line in competition with legitimate vendors. The techniques for thwarting this kind of piracy are quite different from those proposed in the pending legislation.

I commend the subcommittee for grappling with this very difficult problem. Just because there may be loopholes in the regulatory mechanism doesn't necessarily imply that the legislation addressed to the most obvious sources of piracy should not be undertaken. But care must be taken to write legislation that will not penalize computer manufacturers and owners who are not in the audio business at all but use the same technology.

Thank you, sir.

Mr. HUGHES. Thank you, Dr. Lebow.

[The prepared statement of Dr. Lebow follows:]

SUMMARY STATEMENT BY IRWIN J. LEBOW BEFORE THE SUBCOMMITTEE ON INTELLECTUAL PROPERTY AND JUDICIAL ADMINISTRATION OF THE HOUSE JUDICIARY COMMITTEE REGARDING H.R. 3204, FEBRUARY 19, 1992.

My purpose in appearing before the Subcommittee is to provide some technical background to the proposed legislation. The Bill constitutes an important step in enabling digital audio technology to thrive in an uninhibited way. Its potential problems relate not to its intent but to the difficulty of writing a law that does the job without impinging on the rights of others. The source of this difficulty is inherent in the technology.

The single aspect of digital audio technology that has prompted this proposed legislation is its extremely high fidelity or accuracy as compared to that achievable with analog technology. An analog recording on a long-playing record or tape deviates from the original in substantial ways. In contrast, a digital recording is almost an exact replica of the original audio, and a rerecording from a digital recording preserves this same accuracy. Once tape and disc technology was developed that made rerecording available to the consumer, the problem of piracy assumed an importance that it never had before with the lower-quality analog rerecording. And that is why that part of the Bill that requires use of the Secure Copy Management System (SCMS) to preclude making second-generation copies of digital recordings is so important.

The potential problem with the proposed legislation lies in the way in which it defines DAR technology. The same storage media used for audio are used for all the other kinds of information. Digital audio equipment is, in reality, special-purpose computing equipment dedicated to audio use. General-purpose computers are used for a wide variety of purposes that may include audio storage and retrieval, emulating the special-purpose audio equipments. But it is very difficult if not impossible to regulate audio reproduction with this general-purpose equipment when it may not be used for audio at all. If the legislative definitions are narrow, it is possible that piracy can be committed through the use of general-purpose computers. If, on the other hand, the definitions are too loose, then computer users with no interest in audio may be penalized. My interpretation of the Bill's definitions of "digital audio interface device," "digital audio recording device," and "digital audio recording medium" is that they are overly loose.

The Subcommittee should also be aware that in the future the main piracy threat may come from high-quality digital music obtained either over the air or via cable and redistributed illegally in the same way rather than via a recording medium. The techniques for thwarting this kind of piracy are quite different from those proposed in the pending legislation.

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STATEMENT BEFORE THE SUBCOMMITTEE ON INTELLECTUAL PROPERTY AND JUDICIAL ADMINISTRATION OF THE HOUSE JUDICIARY COMMITTEE REGARDING H.R. 3204, FEBRUARY 19, 1992.

I am pleased to have been invited to testify before this Subcommittee on the subject of H.R. 3204, the Audio Home Recording Act of 1991. I am in no way connected with either the recording industry or the electronic equipment industry. Nor have I ever had any direct experience with these industries. I am an engineer with many years of experience in digital communication and computer technology applied to other fields. As I observed how ubiquitous digital technology was becoming and, especially, how the compact disc was revolutionizing the audio recording industry, I was prompted to write a book for the general reader covering the basics of this technology as it applies to computers, communication, and music. This book, *The Digital Connection: A Layman's Guide to the Information Age*, was published a little over a year ago.

My purpose, therefore, in appearing before the Subcommittee is to provide some technical background to the proposed legislation. The Bill provides a prescription for the peaceful coexistence of music copyright holders and the manufacturers of digital audio recording (abbreviated DAR) technology. As such, it constitutes an important step in enabling digital audio technology to thrive in an uninhibited way. The potential problems with the proposed legislation relate not to its intent but to the diffi-

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culty of writing a law that does the job without impinging on the rights of others. The source of this difficulty is inherent in the technology.

I will touch upon three main topics: 1) the distinguishing features of the newer digital technology as opposed to the older analog technology; 2) the relationship of DAR technology to the more general digital computer technology; and 3) some future trends in the information technology industry that will further complicate the issue of protecting intellectual property in the years to come.

The single aspect of digital audio technology that has prompted this proposed legislation is its extremely high fidelity or accuracy as compared to that achievable with analog technology. The signals obtained from playing a compact disc are almost exactly the same as those that were originally generated in the recording studio. In contrast, the signals obtained from a long-playing record usually deviate from the original in more substantial ways. This is why the recording industry is much more concerned about piracy in the digital age than it ever was before when recordings were analog.

The reason for this is fundamental. An LP record is cut so that its sound track is as close as possible to a replica of the electrical signal coming out of the microphones. Similarly, the record player attempts to reproduce the electrical signal from this sound track as accurately as it possibly can. The problem is that both the recording and playback operations are made up of a series of complex processes, and at every step the signal is distorted just a little bit. A familiar example of one source of

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distortion is the way a phonograph pickup needle causes physical abrasions on the record surface leading to the unpleasant effect known as "record scratch." While the distortion at each step may be very small, the cumulative effect of the many processes can be substantial.

In the compact disc, the audio in the recording studio is converted to a stream of digits, and it is these digits that are cut into the disc. The digital CD recording and playback processes are just as complex as those of the analog LP, and potential distortions are there at each step. But there are techniques that guarantee that the digits stored on the disc are exactly the same as those generated from the audio in the studio and that the digits retrieved from the disc are almost exactly the same. These techniques are similar to those used to guarantee accuracy when digits are sent from one computer to another, as when, for example, funds are electronically transferred from one bank to another. This same digital communication employed by the long-distance telephone companies is what makes most of today's long-distance telephone calls sound as good as local calls. The reasons for this extraordinary accuracy are addressed in Note 1.

Since a digital recording is an exact replica of the recorded audio, it follows that rerecording from a digital recording preserves this same accuracy. Once tape and disc technology was developed that made rerecording available to the consumer, the problem of piracy assumed an importance that it never had before with the lower-quality analog rerecording. And that is why that

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part of the Bill that requires use of the Secure Copy Management System (SCMS) to preclude making second-generation copies of digital recordings is so important.

The potential problem with the proposed legislation lies in the way in which it defines DAR technology. Should it be so broad as to include general-purpose computer equipment that may record audio just as it records other data? The fundamental reason for the question is that equipments that record and playback digits don't care about the source of the digits. (To paraphrase Gertrude Stein, a digit is a digit is a digit regardless of where it comes from.) These digits can represent the Library of Congress catalogue, airline schedules, bank balances, or atmospheric pressures as well as a Beethoven symphony.

The same storage media used for audio are used for all the other kinds of information. For example, the device called the compact disc read-only memory (abbreviated CD-ROM) is commonly used to store encyclopedic information including audio. A CD-ROM reader, very similar to a CD player, is available to computer users at a nominal cost. More to the point, the so-called erasable compact disc or magneto-optic disc, which differs from the familiar CD in that it can, like magnetic tape, be used for rerecording audio, is also used by some computers for general storage purposes in place of the more familiar floppy or hard disks. Digital audio equipment is, in reality, special-purpose computing equipment dedicated to audio use. General-purpose computers are used for a wide variety of purposes that may include audio storage and retrieval, emulating the special-purpose audio equipments. But it is very difficult if not impossible to

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regulate audio reproduction with this general-purpose equipment when it may not be used for audio at all. If the legislative definitions are very strict, piracy can be committed through the use of general-purpose computers. If, on the other hand, the definitions are too loose, then computer users with no interest in audio may be penalized. My interpretation of the Bill's definitions of "digital audio interface device," "digital audio recording device," and "digital audio recording medium" is that they are overly loose and can be interpreted to apply to general-purpose computing subsystems that may or may not be used for audio recording. [Note 2]

Finally the Subcommittee should be aware of some possible future developments germane to intellectual property rights. The Bill recognizes that piracy can occur both from storage media and from broadcasts. Today the latter is no threat since there is no digital broadcasting, and even the best FM broadcasting gives lower quality than a record. But people are now experimenting with digital audio broadcasting and, in all probability, it will be distributed commercially in not too many years. The World Administrative Radio Conference now under way is considering requests for a frequency allocation for this service. Over-the-air digital broadcasting will always be limited by bandwidth constraints. But later on, huge capacities will be available with door-to-door optical cable, constituting, in effect, an on-line information market place. Subscribers will be able to make a selection of a variety of information sources including audio or video which will be delivered to the home information center

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almost instantly as a stream of digits. The home information center will be general-purpose, including the ability to store audio, video, and textual information.

It is not inconceivable that this will be the primary way in which people obtain their recordings 10 or 15 years from today. If everything ever recorded is available in this way at a reasonable price, then why own records or tapes? In this situation, piracy will consist of storing audio and video and then distributing it on-line in competition with legitimate vendors. The techniques for thwarting this kind of piracy are quite different from those proposed in the pending legislation.

I commend the Subcommittee for grappling with this very difficult problem. Just because there may be loopholes in the regulatory mechanism doesn't necessarily imply that the legislation addressed to the most obvious sources of piracy should not be undertaken. But care must be taken to write legislation that will not penalize computer manufacturers and owners who are not in the audio business at all but use the same technology.

NOTES

1. There are two aspects to the recording or communication of audio digitally. First, the audio must be converted from analog to digital form accurately enough so that when the digits are reconverted to analog, the original signal is recovered. Then the digits must be recorded or communicated with high accuracy in the face of noise and other distorting effects. The conversion from analog to digital is done by taking samples of the audio and then converting each sample to a number. It can be shown mathe-

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matically that if these samples are taken often enough and if the numbers representing each sample have enough decimal points, then the process of converting from analog to digital and back again is virtually perfect. In the second process, there are mathematical techniques for adding redundancy to the audio digits to overcome the effects of the noise and distortion. For a more extensive explanation of these processes, see Irwin Lebow, *The Digital Connection*, Chapters 6, 7, and 8, W. H. Freeman and Company, New York, 1990.

2. Since a general-purpose computer can "supply a digital signal through a nonprofessional interface," it meets the definition of a "digital audio interface device." A digital storage device for general-purpose use may be indistinguishable from one used for audio recording and therefore meets the definition of a "digital audio recording device." Similarly a general purpose storage medium may be indistinguishable from a "digital audio recording medium." For more details see Owen C. B. Hughes, *Digital Audio Recording: A Look at Proposed Legislation*, New York Law Journal, October 1, 1991.

Mr. HUGHES. Dr. Green, welcome.

STATEMENT OF WAYNE GREEN, PH.D., PUBLISHER, CD REVIEW MAGAZINE, AND SECRETARY, INDEPENDENT MUSIC PRODUCERS SOCIETY, HANCOCK, NH

Dr. GREEN. Thank you. I am Wayne Green, publisher of CD Review magazine and the secretary of the Independent Music Producers Society with about 2,000 independent record companies as members.

I have a digital audio recording studio and I have several record labels, a distributing company, and so forth. I feel somewhat like the youngster that was facing the tanks at Tiananmen Square, and I will remember what happened to him. I believe they eventually executed him. But I am holding up my hand to try to stop things. I do not know of any of the independent record companies that favor this type of a movement.

I have attended the panels at consumer electronic shows for the last several years where we have had Senators and Representatives there testifying and telling us, and the story has been consistent. They have said every time, We will not put through legislation to prevent copying of digital information unless we have proof that there have been losses. You have no proof. You have speculation. You have unsubstantiated figures of a billion dollars in losses. Make it \$10 billion. We have no proof of anything like that.

Congress has heard these stories before. When the audio analog cassette came along, there was testimony that this would destroy the music industry. It turned out to be the biggest bonanza the music industry has ever had. Half of all music sales are on prerecorded cassettes. When the video tape recorder came along, testimony before Congress that this would absolutely, positively, without a doubt destroy the movie industry. It has been the biggest bonanza the movie industry has ever had. They are making more money from their prerecorded videocassettes, than they are from the theaters. I see this pattern being played over and over.

There are technical problems, as the doctor pointed out. One of the things that I have issued is a CD-ROM which lists all of the compact disks that are available, complete with any imaginable kind of cross-indexing. But it also has full-color pictures of the covers of many of them and samples of the music. So it is a combination for computers of music, video and data information.

I have been the editor and publisher in the past of a number of computer magazines, so I am not unfamiliar with digital data. And what we are storing on our compact disks, what we are storing on our digital audio tape is 0's and 1's, the same thing that we use for computer programs, the same thing that we use for computer data, and this is just a different kind of computer output that reads it into our earphones and our speakers.

Now digital audio broadcasting was mentioned. Digital audio broadcasting is coming. There is no way to stop it. The preliminary tests show that it is enormously advantageous over FM. And, indeed, tests over in the UK have shown that with .001 of the power you get about 10 times greater coverage, and instead of having one channel of music, you have six channels of music on each fre-

quency. So that we are going to have an enormous amount of digital materials going over these broadcasting stations.

I think that there are some hidden agendas here. Digital audio tape is pretty much, as far as the consumer is concerned, a dead technology. The consumers have been able to buy these for several years whenever they wanted, and they have not bought them because there is not much use in normal consumer applications for digital tape. We use it in our recording studio because it beats the heck out of anything that we had previously.

But coming soon are DCC (digital compact cassette) and the minidisk, and we have some Thor technology from Tandy, and we have a number of these things coming. As I say, I am just a small person speaking up in this mass of million dollar companies that are pushing for this and lobbying for it, and I see the ulterior motives of controlling these new technologies.

Now, you listened to the test here. How many of you would be willing to bet money on whether you were hearing an audio of an analog cassette, a digital cassette or a compact disk? The difference is really very small between a good analog cassette and a compact disk, and the difference actually with DCC, the engineers tell me that that sound is not as good as a good analog cassette. But it has the advantage of being able to play both a digital type of music, where they throw away 80 percent of the digital information, and an analog in the same machine.

The same thing goes for the minidisk, the MD, which will be coming out probably next year, where they throw away about 75 percent of the digital information. And again, it is not as good to the ear, according to the engineers that I have talked with at Panasonic, as a good analog cassette.

Now, if this goes through, if this legislation goes through I can tell you one of the first things that is going to happen is that 10,000 hackers are going to figure out how to change that 0 to a 1 on your data stream. And it is going to be simple to do. We have a very similar situation in the radio field, where they were selling radios to CBers and they said, "Do not cut this red wire," because it will make it so that you can transmit outside of the CB band. Well, tens of thousands of people cut that red wire, and the FCC has never been able to stop them. They are operating outside of the normal legal bands and there has been no way to stop it.

In my magazine, I suspect, there will be articles very quickly on how to convert consumer DAT machines so that they no longer have copy protection. Because the consumer machines normally will be less expensive, and I think many of our recording engineers are going to buy those and do the conversion. And the word will get out because these computer hackers are going to be able to solve this in minutes. If they can get into your biggest data bases in the country, they are going to be able to solve something simple like this.

So I am not in favor of doing this. I think that you have a few—and I have heard all of these testimonies, the same things that I was hearing when the analog cassette came along—word for word, virtually—about the destruction of the industry. I see no such destruction. I see only more and more sales.

The home recording has not been a problem. We have done studies of this. So few people are making copies for friends. They do make a copy to play in the car or to play in their Walkman, and you are permitting that, so that is no change.

Another aspect of it is, if you start with digital information from a compact disk or a digital audio tape and you go through an analog stage, it removes the digital encoding totally, and then you go back to digital again and you won't hear the difference. You cannot hear the difference. Yes, you have gone through an analog stage, but the difference is so minute that I don't think even the editor of the most high-end magazines are going to be able to tell the difference.

So I don't see that we are gaining anything or doing anything here. I recognize the problems, and I think there must be other ways to solve these problems rather than hamstringing a new technology.

Thank you.

Mr. HUGHES. Thank you, Dr. Green.

[The prepared statement of Dr. Green follows:]

