January 12, 1967

Mr. James J. Costello
Legal Counsel
University of Illinois
258 Administration Building
Urbana, Illinois

RE: UIF v. BT v. JFD

Dear Mr. Costello:

On December 16, 1966, I sent you a copy of a subpoena in the above suit with regard to certain materials relating to Contract AF33(616)-6079 Project No. 9-(13-6278) Task 40572. We have just learned that our request was too limited and should have called for all the specified materials relating to the Contract AF33(616)-6079. I

* enclose a copy of a further subpoena which we have directed to Mr. Lawler with regard to these materials.

Very truly yours,

Richard S. Phillips

RSP:ieg

* Enclosure

cc: Mr. Harold B. Lawler
Mr. Basil P. Mann
Mr. Myron C. Cass
Mr. Robert H. Rines
Mr. I. S. Blonder

LAW OFFICES
Silverman & Cass
PATENTS · TRADEMARKS · COPYRIGHTS
105 W. ADAMS STREET · CHICAGO, ILLINOIS, U.S.A. 60603
TELEPHONE 726-6006
AREA CODE 312
CABLE: SILCAS
I. IRVING SILVERMAN
MYRON C. CASS
SIDNEY N. FOX
GERALD R. HIBNICK, IND. BAR

February 2, 1967

Our Ref. 6-418

Richard S. Phillips, Esq.
Hofgren, Brady, Wegner, Allen,
Stellman & McCord
20 North Wacker Drive
Chicago, Illinois 60606

RECEIVED
FEB 3 1967
HOFGREN, WEGNER, ALLEN,
STELLMAN & McCORD

Re: UIF v. BT v. JFD - Civil Action No. 66 C 567

Dear Dick:

Continued search for materials which you requested has located blueprints of JFD antennas and parts therefor which are proposed to be used in attacking validity of the B-T patent in suit. With respect to the enclosed JFD drawings 52720, 52730 and 50451, I am advised that the drawings were made after each of the mechanical components illustrated had been designed and the tools built. Obviously, this would be long after the research and development work was done with respect to the components. I am advised that these assembly drawings would have been made sometime between nine months to one year after the original development of the project.

Per our agreement, dimensions of the antenna elements have been removed.

With respect to the enclosed JFD drawings 11881-0101 and 01201140, there is shown a strain relief member used since the middle of 1962 and is still in use on JFD antenna model 10Y1013G illustrated.

Very truly yours,

SILVERMAN & CASS

Myron C. Cass

Myron C. Cass

MCC/gm
Encl.
cc: Basil P. Mann, Esq.

February 6, 1967

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

* I enclose a copy of a letter from Cass together with copies of JFD drawings which purportedly show twin boom antennas early in 1964. There is also a part drawing for a strain relief member.

I am sending a set of the drawings to Ike also so that he can bring them along if he attends Finkle's deposition on Wednesday.

* I also enclose another notice of prior art from JFD.

Very truly yours,

Richard S. Phillips

RSP:iag

* Enclosures

cc: Mr. I. S. Blonder (with enclosures)

LAW OFFICES

HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD

20 NORTH WACKER DRIVE
CHICAGO 60606

TELEPHONE
FINANCIAL 6-1630
AREA CODE 312

C/RHR 10/19

Enr.

October 17, 1967

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

We are scheduled to report for trial call again next Monday. The criminal trial is still going on, although it may go to the jury before the week is over. Judge Hoffman's clerk is no help at all. He says to check back Thursday or Friday and he will tell us whether we should be prepared to start the trial on Monday. I have talked with an attorney involved in the antitrust case which has been ahead of us. They will put over to November 15 because of the illness of a principal trial counsel. I have been unable to reach the attorney involved in the other patent case which was also ahead of you. As soon as I learn the present status of his case, I will let you know. I will let you know Thursday or Friday whether you should plan to be here Monday.

Very truly yours,

Dick

Richard S. Phillips

RSP:iag

cc: Mr. I. S. Blonder

RECEIVED
OCT 19 1967
RINES AND RINES
NO. TEN POST OFFICE SQUARE, BOSTON

LAW OFFICES

HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD

20 NORTH WACKER DRIVE

CHICAGO 60606

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FINANCIAL 6-1630
AREA CODE 312

October 19, 1967

VIA AIR MAIL

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

* I enclose copies of an affidavit and motion for rescheduling the trial. I understand you will be back in your office tomorrow afternoon. Please call me as soon as possible with your comments and suggestions. The papers have to be served on opposing counsel by four o'clock and with the judge's clerk by 4:30 in order to present the motion on Monday. I need more information on your trip. If it is merely a vacation, Hoffman won't pay any attention to it, and I don't want to put it in the affidavit. On the other hand, if you are there on business that can't wait, it may be helpful.

Yours very truly,

Dick

Richard S. Phillips

RSP:iag

* Enclosures

LAW OFFICES

HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD

20 NORTH WACKER DRIVE

CHICAGO 60606

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AXEL A. HOFGREN
ERNEST A. WEGNER
JOHN REX ALLEN
WILLIAM J. STELLMAN
JOHN B. McCORD
BRADFORD WILES
JAMES C. WOOD
STANLEY C. DALTON
RICHARD S. PHILLIPS
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JAMES R. SWEENEY
W. E. RECKTENWALD
J. R. STAPLETON

WILLIAM R. McNAIR
JOHN P. MILNAMOW
DILLIS V. ALLEN
W. A. VAN SANTEN, JR.
JOHN R. HOFFMAN

October 23, 1967

VIA AIR MAIL

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

After I talked with you I talked with an attorney involved in one of the cases which is still ahead of yours. As nearly as we can estimate at this time, when the present criminal case is completed (possibly this week), a patent infringement suit will go to trial and last for probably two to three weeks. Following this is a private antitrust action, presently scheduled for November 15, which may take as long as four to six weeks.

When these two cases have been completed, Judge Hoffman will be extremely anxious to try your case as it will then be the oldest on his calendar. I will keep you advised from time to time, but I recommend very strongly that you and Ike keep your calendars clear from the middle of December on.

Very truly yours,

Dick

Richard S. Phillips

RSP:iag

cc: Mr. I. S. Blonder

LAW OFFICES
HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD
20 NORTH WACKER DRIVE
CHICAGO 60606

TELEPHONE
FINANCIAL 6-1630
AREA CODE 312

October 20, 1967

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

* I enclose copies of the notice, motion and affidavit in connection with the above.

I talked with John Pearn's local counsel and found that Judge Lynch has again postponed a planned meeting for the announcement of his decision on the motions, and a pretrial conference. It is now scheduled for next Friday, October 27. I will be out of town but Mr. Wyss will let my secretary know what happens and she will write you.

Very truly yours,

Dick

Richard S. Phillips

RSP:iag

* Enclosures

RECEIVED
OCT 25 1967
RINES AND RINES
NO. TEN POST OFFICE SQUARE, BOSTON

BLONDER·TONGUE LABORATORIES INC.
9 ALLING STREET, NEWARK, NEW JERSEY 07102 · (201) 622-8151

October 27, 1967

Mr. Robert Rines
10 Post Office Square
Boston, Massachusetts

Dear Bob,

I am attaching a transcript of the interviews conducted by my assistant with various people on the subject of JFD piracy. I have checked and underlined those areas which may be pertinent. I am including the entire interview report so that you get a true picture of what happened in case there are any problems presented at the trial.

You will note that there are very few direct comments or first-hand knowledge of the piracy. The evidence is primarily circumstantial with the best witness being me.

If there is anything else we can do to give you additional help, please telephone.

Sincerely,

Sheldon Williams
Vice President - Personnel

SW:gfb

October 19, 1967

Sheldon Williams spoke to Ed Elizondo on the telephone on October 14, 1967.

I asked him point-blank how come he took the job at JFD. He said that Tom Shea, Manager of the MATV Division at JFD, had contacted him several times and asked him to come to JFD and that he finally did meet with Tom, who played up a rather glorified position which turned out to be more in imagination than in reality.

I do not think that Ed would testify. Ed said that onee at JFD he called Abe Schenfeld at Tom's request.

October 19, 1967

Sheldon Williams spoke to Abe Schenfeld the day he left B-T's employ (6/3/67).

When I querried Abe about whether he had approached JFD or whether JFD had approached him, he hedged and refused to answer. Inspite of several requests, I could not get him to give me a yes or no answer. His behavior lead me to believe that he had been recruited and this was later confirmed by Ed Elizondo.

October 19, 1967

I spoke to Graham Sisson many times prior to his departure. He told me that Tom Shea had been after him to come and join JFD for some months. Graham informed me that Tom wined and dined him at the June Parts Show trying to convince Graham to come. Tom repeated the cajolery throughout the months of August and September.

Sheldon Williams

October 25, 1967

Spoke with Jerry Cohn about Graham Sisson on 10/25/67 (at Alpha Wire).

Jerry could only tell me what happened before he left (August 25th). He related the following facts: At the New Show in Chicago, Graham had a disagreement with Leon Knize. Graham was upset because of the operating conditions under which he worked. He wanted a West Coast office and a central warehouse, better communications with the main office, and a more-defined, operational program. Graham, however, did get a salary increase; but the rest of his grievances went virtually unanswered. Jerry did not know whether Graham was approached by JFD, because he did not talk to him at that particular time and has not since. Jerry, himself, admitted that he went to JFD for a job. He ended our conversation with..."Where else is there to go really? There are only a handful of companies in this area which deal in the same product line, so....

October 25, 1967

Gail Bogues spoke with George Scherer on 10/24/67 about Abe Schenfeld.

George did not know the specifics about Abe's leaving. He spoke to Abe in a general way; but, Abe, of course, did not mention whether he was approached by JFD or not. [George felt that if JFD were going to approach anyone in Engineering, it would be Ed or Abe. He felt that it was more than a coincidence that both left within a short time of each other.]

Spoke with George Scherer on 10/23/67 about Ed Elizondo.

George spoke of Ed's dissatisfaction with the job and his growing boredom with the scope of his job. He felt that it would have been only a matter of time before Ed left on his own. In fact, he feels that he filed an application at RCA before taking the job at JFD. [As far as JFD is concerned, he does not know whether JFD approached Ed or whether he applied there, also. Ed never told George how he got the job, and George never heard from anyone else in the lab anything that would lead him to have firm convictions that Ed was pirated.] But, George felt that Ed would have been sworn to secrecy anyway.

Spoke with George Scherer on 10/24/67 about Bob Mankedick.

George heard about Bob's leaving through the grapevine and did not speak to Bob personally about how he left BT. He was aware that Bob was very unhappy about three fellows in the lab receiving sizeable increases when he did not get anything. Bob felt that he was doing the same work as they were and was getting the raw end of the stick. Because of this dissatisfaction, he was a perfect candidate for JFD's recruiting, if, in fact, there was any.

October 25, 1967

Spoke with Sam Stone on 10/19/67 about Graham Sisson's resigning to go to JFD.

Sam assumes that Jerry Balash, who is a close friend of Graham's, first approached Graham about coming to JFD. Jerry Balash has worked for JFD approximately two years and probably told Tom Shea to get in touch with XXX Graham. When Tom opened the new MATV Division, he probably kept plugging to get Graham until he finally succeeded.

Spoke with Ernie Sisson on the telephone on 10/19/67 about Graham Sisson.

What he might know about the situation and what he told me are two different stories. He said he know nothing, but assumes that JFD got in touch with Graham first.

Spoke to Leon Knize on 10/23/67 about Graham Sisson.

Leon said that he did not know any of the particulars. When he spoke to Graham, the latter did not mention who approached whom. Leon only assumes, based on hearsay, that Graham was approached by Tom Shea of JFD repeatedly. He also mentioned the possibility of Jerry Balash telling Tom Shea since Jerry and Graham are old friends.

October 26, 1967

Spoke to Ned Sampson on 10/25/67 about Abe Schenfeld.

Ned said that the grapevine had it that Abe approached JFD himself. There was a definite difference of opinion on approach between Abe and Irv, which did not resolve itself, and became a personality clash--thereby widening the gap of understanding between the two individuals.

Spoke to Ned Sampson on 10/25/67 about Ed Elizondo.

Ed was supposedly approached by JFD, but feels that Ed was looking around anyway. Ed did tell Ned that he had applied to be a civilian in space and was turned down by the National Aeronautical Space Agency. Ed felt that he had reached a deadend on his job. Ed likes basic research the best, and he did not have too much of an opportunity to do this at B-T.

Spoke to Ned Sampson on 10/25/67 about Bob Mankedick.

Ned was more intimate with the details of Bob's separation. Bob openly told Ned that he lost confidence in Company management. Bob got wind of three fellows in the lab who were given raises, and Bob felt that he did not get a fair treatment. This lead to disenchantment on his part. Ben Tongue had praised him to the hilt, yet Bob got nothing, and the other fellows got all the gravy.

Also, Bob complained about lack of decision-making by management. Where was the Company going? Did the Company show any positive direction?

The crowning glory came when he told the Company that he was leaving. Then, he was offered free parking, quite a sizeable raise, etc. This had a negative effect on him rather than a positive one. He felt that he had to scream before he would get results.

Steve Evanko accused Bob, after the fact, of taking things belonging to the Company out of the Company in his briefcase.

In closing, Ned did not know whether Bob had been approached or not.

October 26, 1967

Spoke to Irv Horowitz on 10/25/67 about Ed Elizondo.

Irv is quite certain that Ed was approached by JFD. The surface reason Ed gave to Irv for leaving was that JFD offered him a position as Chief Engineer. Underlying reason was that Ed did not like the work he was doing here. Ed's real love is research and development.

Spoke to Irv Horowitz on 10/25/67 about Abe Schenfeld.

Irv feels that Abe wanted to leave, and does not know if Abe was approached. In all probability, he applied himself, since this presented a great opportunity for him. Irv stated that he and Abe did not get along. He further mentioned that Abe was not interested in research and development, but preferred administrative work.

October 25, 1967

Spoke to Ben Tongue on 10/25/67 about Ed Elizondo

Ben felt that Ed had decided to look around when George Kaplan left because he felt growth would discontinue when Irv Horowitz took over. Ben did not know whether Ed was solicited or not. Ed might have felt that his product would prove to be unmanufacturable when it came out.

Spoke to Ben Tongue on 10/25/67 about Abe Schenfeld.

Ben mentioned that Irv had insulted Abe a number of times publically. He felt that Abe was dissatisfied and was probably looking on his own anyway. When Ed Elizondo decided that he did not like JFD, he left JFD and went to RCA. Ben feels that Abe was contacted by Ed Elizondo.

Spoke to Ben Tongue on 10/25/67 about Bob Mankedick.

Bob was supposedly unhappy with insufficient lack of guidance and instruction given to him from his supervisor. He was involved with a product that demonstrated troubles after being pre-piloted. He might have been concerned about this. He does not know whether JFD contacted Bob or not.

LAW OFFICES

HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD

20 NORTH WACKER DRIVE

CHICAGO 60606

TELEPHONE
FINANCIAL 6-1630
AREA CODE 312

October 30, 1967

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

The hearing in the Finney suit was again postponed. Apparently Judge Lynch is ill but no one is admitting it publicly. If anything should develop, I will let you know promptly.

I'll be out of town the week of Thanksgiving.

Very truly yours,

Dick

Richard S. Phillips

RSP:iag

LAW OFFICES
HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD
20 NORTH WACKER DRIVE
CHICAGO 60606

TELEPHONE
FINANCIAL 6-1630
AREA CODE 312

October 30, 1967

Miss Marjorie A. Johnson
3405 Twenty-First Street
Rock Island, Illinois

RE: University of Illinois Foundation
v. Blonder-Tongue Laboratories

Dear Miss Johnson:

I am writing to let you know that we have not forgotten you completely. The trial of the lawsuit against Blonder-Tongue Laboratories has again been postponed and is presently scheduled for December 18. It is probable that Mr. Rines, Blonder-Tongue's attorney, will be in Chicago before that time for some preparatory work in connection with the trial; and would like to talk with you. When I learn his plans for coming here, I will be in touch with you. We hope it will be convenient for you to come to Chicago and meet with us.

Very truly yours,

Richard S. Phillips

RSP:iag

cc: Mr. Robert H. Rines

October 27, 1967

Mr. Sheldon Williams
Blonder-Tongue Laboratories
9 Alling Street
Newark, New Jersey 07102

Dear Sheldon:

Your suggestion that you hope to be able to give me information of JFD piracy later in the month is welcomed.

We can at that time discuss the further matter of Viking.

Very truly yours,

RINES AND RINES

RHR/BD

By____________________________

Form

BLONDER-TONGUE LABORATORIES
9 ALLING STREET
NEWARK, N. J. 07102

PLEASE RETURN THIS

Speed Reply

TO

October 18, 1967
DATE

To Mr. Robert Rines
10 P.O. Square
Boston, Massachusetts

SUBJECT

Message

Dear Bob,

When do you need the information you asked for on the JFD piracy of our employees. If we get it to you be the 27th, is that soon enough?

SW

Sheldon Williams
SIGNED

ORIGINATOR—DO NOT WRITE BELOW THIS LINE

ORIGINATOR FOLD MARKS

ADDRESSEE FOLD MARKS

Reply

TO ______ DATE ______

SIGNED

ADDRESSEE—RETURN WHITE COPY

Form

BLONDER-TONGUE LABORATORIES
9 ALLING STREET
NEWARK, N. J. 07102

PLEASE RETURN THIS
Speed Reply
TO

October 23, 1967
DATE

SUBJECT

To Mr. Robert Rines
10 Post Office Square
Boston, Massachusetts

Message

While we were busy concentrating our fire on the JFD pirate on the port side, the Vikings have attacked again on the starboard. As I mentioned the other day, they recruited one of our General Foremen and now at least two of our technicians have been offered jobs at substantial raises. We believe that factory supervisors and other administrative personnel have been approached.

I know that they signed some sort of agreement not to raid. Can you help?

Shel.
Sheldon Williams
SIGNED

ORIGINATOR—DO NOT WRITE BELOW THIS LINE

Reply

TO DATE

P.S. [illegible] something to tell you about relating to this event

Sn

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OCT 24 1967
RINES AND RINES
NO. TEN POST OFFICE SQUARE, BOSTON

SIGNED

ORIGINATOR FOLD MARKS

ADDRESSEE FOLD MARKS

ADDRESSEE—RETURN WHITE COPY

Form

BLONDER-TONGUE LABORATORIES

9 ALLING STREET

NEWARK, N. J. 07102

PLEASE RETURN THIS

Speed Reply

TO

October 23, 1967

DATE

To Mr. Robert Rines
10 Post Office Square
Boston, Massachusetts

SUBJECT

Message

While we were busy concentrating our fire on the JFD pirate on the port side, the Vikings have attacked again on the starboard. As I mentioned the other day, they recruited one of our General Foremen and now at least two of our technicians have been offered jobs at substantial raises. We believe that factory supervisors and other administrative personnel have been approached.

I know that they signed some sort of agreement not to raid. Can you help?

Shel

SIGNED

ORIGINATOR—DO NOT WRITE BELOW THIS LINE

Reply

TO ______________________ DATE ____________

SIGNED

ORIGINATOR—DETACH THIS PART—FORWARD BALANCE OF SET INTACT

ORIGINATOR FOLD MARKS

ADDRESSEE FOLD MARKS

LAW OFFICES
HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD
20 NORTH WACKER DRIVE
CHICAGO 60606

AXEL A. HOFGREN
ERNEST A. WEGNER
JOHN REX ALLEN
WILLIAM J. STELLMAN
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JOHN P. MILNAMOW
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October 31, 1967

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NOV - 1 1967
RINES AND RINES
NO. TEN POST OFFICE SQUARE, BOSTON

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

* I enclose a copy of the Foundation's brief on appeal in the Winegard suit.

Very truly yours,

Dick

Richard S. Phillips

RSP:iag

* Enclosure

McNENNY, FARRINGTON, PEARNE & GORDON
ATTORNEYS AT LAW
920 MIDLAND BUILDING
CLEVELAND, OHIO 44115

F. O. RICHEY (1878-1964)
HAROLD F. McNENNY
DONALD W. FARRINGTON
JOHN F. PEARNE
CHARLES B. GORDON
WILLIAM A. GAIL
RICHARD H. DICKINSON, JR.
THOMAS P. SCHILLER
LYNN L. AUGSPURGER

TELEPHONE
(216) 623-1040
CABLE ADDRESS
RICHEY
PATENT AND
TRADEMARK LAW
LLOYD L. EVANS
OF COUNSEL

November 1, 1967

Robert H. Rines, Esq.
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

Re: The Finney Company v. JFD et al.

Dear Bob:

Since I last wrote to you, the call of the above suit for disposition of our Motion for Summary Judgment and consideration of a trial date has been postponed two more times. The new date is November 15.

Sincerely,

John

JFP:jh

cc: Richard S. Phillips, Esq.

LAW OFFICES
MASON, KOLEHMAINEN, RATHBURN & WYSS
20 NORTH WACKER DRIVE
SUITE 3200
CHICAGO, ILLINOIS 60606

RICHARD D. MASON
WAINO M. KOLEHMAINEN
M. HUDSON RATHBURN
WALTHER E. WYSS
REGINALD K. BAILEY
WILLIS J. JENSEN
ROBERT L. ROHRBACK
WARREN D. McPHEE
CLEMENS HUFMANN
ANDREW J. BOOTZ
PHILIP C. PETERSON
PHILIP M. KOLEHMAINEN

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TELEPHONE FINANCIAL 6-1677
CABLE ADDRESS: MAKRAW

RECEIVED
NOV 29 1967
McNenny, Farrington, Pearne & Gordon

November 27, 1967

AIR MAIL

John F. Pearne, Esq.
McNenny, Farrington, Pearne & Gordon
920 Midland Building
Cleveland, Ohio 44115

Re: The Finney Company v. JFD Electronics Corporation and The University of Illinois Foundation - Civil Actions Nos. 65 C 220, 65 C 671 (Cons.)

Dear John:

I just received a note from Pete Mann who in turn got a call from Sid Fox. The gist of the hearsay statements are that Judge Lynch doesn't want anybody to appear in the above-mentioned case this week. He will, however, decide the case in one of three ways.

(1) Grant your motion,
(2) Deny your motion,
(3) Request oral argument.

Keep your fingers crossed.

Cordially yours,

Walt

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DEC - 1 1967
RINES AND RINES
NO. TEN POST OFFICE SQUARE, BOSTON

WEW:aa

November 29, 1967

November 15th date set over to November 29th and then called off as stated above.

J.F.P.

LAW OFFICES

HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD

20 NORTH WACKER DRIVE

CHICAGO 60606

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FINANCIAL 6-1630
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J. R. STAPLETON

WILLIAM R. McNAIR
JOHN P. MILNAMOW
DILLIS V. ALLEN
W. A. VAN SANTEN, JR.
JOHN R. HOFFMAN

November 27, 1967 *gmr/*

VIA AIR MAIL

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

We have been trying to determine what Judge Hoffman will be doing early in December so that we can try to predict whether your trial will start on or about the 18th. A patent case is presently on trial and may finish today. A personal injury suit (presumably short) is supposed to go next. The private anti-trust action is scheduled to report again Wednesday. As nearly as we have been able to determine, you will be next after it. It might go for two or three weeks, but could be over much sooner depending on rulings they expect the court to make during trial.

It is my feeling at the moment that there is an excellent chance that your trial will start before Christmas. I suggest you have Ike and your expert witness ready to go.

Very truly yours,

Dick

Richard S. Phillips

RSP:iag

NOTES RE USE OF INVENTION BEING INFRINGED

Scott & Williams, Inc. v. Hemphill DC 1931 14 F.Supp. 621

"The alleged infringing machine is neither manufactured nor sold here, but it directly strikes me that this use in either is sufficient to constitute infringement. One of the machines is operated here, both as the demonstration to convince buyers of its merit and as a way of making simple stockings to send out to the trade. This is a "use" of the machine (p. 622).

Approved in Marlott v. Mergenthaler Linotype Co., 70 F.Supp. 426, 430-31.

In Patent Tube Corporation v. Bristol-Myers Co., 25 F.Supp. 766 and 777, distribution of the patented device for advertising purposes and without actual monetary compensation is an infringing use.

In Radio Corporation of America v. Andrea, 15 F.Supp. 685, the assembling of parts and adjustment to determine the operability and efficiency were held to be an actionable use. Modified at 90 F.2d 612.

Sprout Waldron & Co. v. Bauer Bros. Co. - A patentable method was used in the production of wood pulp and wallboard. In the machine that they sold this was infringing use, p. 168, 169. See also 165, column 2, last several lines; 167, column 1 at (2); and 169; column 2 (8).

MEMO - Re: <u>University of Illinois v. Blonder-Tongue</u>

We have the testimony of Blonder and the depositions of Gilbert and Helhowski as to what the state of mind of their customers was after visits by JFD salesmen.

Cases supporting the admissibility of what the customers uttered as showing that state of mind--and as distinguished from proof of the facts--as an exception of the hearsay rule are as follows:

Marcalus Manufacturing Co. v. Watson - 156 F.Supp. 161, 164

S. C. Johnson & Son, Inc. v. Johnson - 28 F.Supp. 744, 749

American Luggage Works, Inc. v. United States Trunk Co., Inc. - 158 F.Supp. 50, 53

Household Finance Corp. v. Federal Finance Corp. - 105 F.Supp. 164, 169

The Standard Oil Company v. Standard Oil Company - 252 F.2d 65, 75

Anheuser-Busch, Inc. v. Bavarian Brewing Company - 264 F.2d 88, 93

MEMO - Re: <u>University of Illinois v. Blonder-Tongue</u>

We have the testimony of Blonder and the depositions of Gilbert and Heihowski as to what the state of mind of their customers was after visits by JFD salesmen.

Cases supporting the admissibility of what the customers uttered as showing that state of mind--and as distinguished from proof of the facts--as an exception of the hearsay rule are as follows:

Marcalus Manufacturing Co. v. Watson - 156 F.Supp. 161, 164

S. C. Johnson & Son, Inc. v. Johnson - 28 F.Supp. 744, 749

American Luggage Works, Inc. v. United States Trunk Co., Inc. - 158 F.Supp. 50, 53

Household Finance Corp. v. Federal Finance Corp. - 105 F.Supp. 164, 169

The Standard Oil Company v. Standard Oil Company - 252 F.2d 65, 75

Anheuser-Busch, Inc. v. Bavarian Brewing Company - 264 F.2d 88, 93

Copy sent to Palmer

McNENNY, FARRINGTON, PEARNE & GORDON

ATTORNEYS AT LAW

920 MIDLAND BUILDING

CLEVELAND, OHIO 44115

O. RICHEY (1878-1964)

HAROLD F. McNENNY
DONALD W. FARRINGTON
JOHN F. PEARNE
CHARLES B. GORDON
WILLIAM A. GAIL
RICHARD H. DICKINSON, JR.
THOMAS P. SCHILLER
LYNN L. AUGSPURGER

TELEPHONE
(216) 623-1040
CABLE ADDRESS
RICHEY

PATENT AND
TRADEMARK LAW

LLOYD L. EVANS
OF COUNSEL

December 7, 1967

Robert H. Rines, Esq.
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

Re: The Finney Company v. JFD et al.

Dear Bob:

Judge Lynch summarily denied our motion for summary judgment in accordance with the attached copy of the record entry by the minute clerk. Thus, all we accomplished was to develop rather fully the factual and legal issues on which the same questions will probably depend at the trial.

The last word I received about your case is that it was set for trial December 18, 1967. This would seem to be an unlikely date, but I would like to attend the trial even if it does start at that time. Moreover, I would like to know if you would care to sit down with me before the trial and review such material as I may have that you can use to your advantage.

I shall try to call you or Dick Phillips in regard to the above on Friday, December 8th.

Sincerely,

John

JFP:jh

cc: Richard S. Phillips, Esq.

4

UNITED STATES DISTRICT COURT, NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

Name of Presiding Judge, Honorable WILLIAM J. LYNCH

Cause No. 65 C 770 + 65 C 671 Consolidated Date Nov 29 - 1967

Title of Cause The Finney Company v. JFD Electronics Corpn et al -

Brief Statement of Motion

The rules of this court require counsel to furnish the names of all parties entitled to notice of the entry of an order and the names and addresses of their attorneys. Please do this immediately below (separate lists may be appended).

Names and Addresses of moving counsel

Representing

Names and Addresses of other counsel entitled to notice and names of parties they represent.

Reserve space below for notations by minute clerk

Order Motion of the plaintiff for summary judgment as to Isbell patent 3,210,767 and as to Mayes et al patent Re. 25740 is denied in all respects

WJL

Hand this memorandum to the Clerk.
Counsel will not rise to address the Court until motion has been called.

LAW OFFICES
HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD
20 NORTH WACKER DRIVE
CHICAGO 60606

TELEPHONE
FINANCIAL 6-1630
AREA CODE 312

December 11, 1967

RECEIVED
DEC 13 1967
RINES AND RINES
NO. TEN POST OFFICE SQUARE, BOSTON

VIA AIR MAIL

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

Judge Hoffman's probable schedule is confused, as usual. He has not yet started the trial of the antitrust case. I may know more regarding this before the day is over.

* I enclose a copy of the brief on behalf of Winegard in their suit. I find nothing in the brief regarding the "publication" at the University of Illinois. Most of the discussion is concerned with the prior documentary art and its significance.

I learned last Friday that Marjorie Johnson is now teaching school and will not be readily available to come to Chicago to testify if school is in session. I am writing her to see how much notice she needs before coming to Chicago for a day or so. If she won't be able to do it, I would imagine you could stipulate the use of her testimony from one of the other suits.

Very truly yours,

Dick

Richard S. Phillips

RSP:iag

* Enclosure

PS: I have just talked with Pete Mann. He learned from one of the counsel in the antitrust action that they are going back before the Judge on the 14th. The counsel expressed some doubt whether their trial would start before Christmas. It is a jury case and the court might be reluctant to impose on jurors at this time of the year. On Thursday I hope to be able to tell you whether you should plan to be here Monday morning.

BURMEISTER, KULIE, SOUTHARD & GODULA

135 SOUTH LA SALLE STREET, CHICAGO, ILLINOIS 60603

MARSHALL A. BURMEISTER
KEITH J. KULIE
DONALD B. SOUTHARD
EDMUND A. GODULA

ATTORNEYS AT LAW–FRANKLIN 2-1344, CENTRAL 6-3351

December 8, 1967

Richard Phillips, Esq.
Hofgren, Wegner, Allen,
Stellman & McCord
20 N. Wacker Drive
Chicago, Illinois

RECEIVED
DEC 11 1967
HOFGREN, WEGNER, ALLEN,
STELLMAN & McCORD

Re: UIF -v- Winegard Company
Court of Appeals - 8th Circuit
Appeal No. 19000
Our File: 45-34

Dear Dick:

Enclosed is a copy of our brief on appeal in the above case. We do not have too many extra copies of our Supplemental Record. However, if you wish to borrow a copy to make a xerox reproduction for your files let us know.

The University "blooped" in one respect in their case below. This is with regard to PX-68 where they assert in their brief that documents placed into evidence by us are the same as indicated to be before the examiner in the motion during the interference proceeding. However, they never offered any proof of this during the trial and they did not place the interference file in evidence. Accordingly, they now have no proof of any kind as to what documents were before the examiner. This refers to the DuHamel-Ore publication and the K.O. brochure. They are attempting to show in their brief, as you probably noted, that the presumption of validity is strong since DuHamel and K.O. were before the examiner and the Court below would not recognize this. It was too good a point to pass up and we labored it a bit.

We feel rather good about the appeal, Dick -- especially since it is in the 8th Circuit.

Sincerely yours,

Keith

Keith J. Kulie

KJK:cvw
Enclosure

LAW OFFICES
HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD
20 NORTH WACKER DRIVE
CHICAGO 60606

TELEPHONE
FINANCIAL 6-1630
AREA CODE 312

AXEL A. HOFGREN
ERNEST A. WEGNER
JOHN REX ALLEN
WILLIAM J. STELLMAN
JOHN B. McCORD
BRADFORD WILES
JAMES C. WOOD
STANLEY C. DALTON
RICHARD S. PHILLIPS
LLOYD W. MASON
TED E. KILLINGSWORTH
CHARLES L. ROWE
JAMES R. SWEENEY
W. E. RECKTENWALD
J. R. STAPLETON

WILLIAM R. McNAIR
JOHN P. MILNAMOW
BILLIS V. ALLEN
W. A. VAN SANTEN, JR.
JOHN R. HOFFMAN

December 14, 1967

Miss Marjorie A. Johnson
3405 Twenty-First Street
Rock Island, Illinois

RE: UIF v. BT v. JFD

Dear Miss Johnson:

It is possible that the lawsuit between the University of Illinois and Blonder-Tongue Laboratories may be reached for trial shortly. I understand from John Pearne, the attorney for The Finney Company, that you are now teaching school and not free to come to Chicago on short notice, as you were last year. Please call me collect, either at the office or at my home (CRestwood 2-2024, Northbrook, Illinois) in the evening or over the weekend, if that is more convenient. We are involved in the lawsuit only as local representatives of a lawyer who will handle the trial. I wish to let him know your situation.

Very truly yours,

Richard S. Phillips

RSP:iag

cc: Mr. R. H. Rines

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DEC 15 1967
RINES AND RINES
NO. TEN POST OFFICE SQUARE, BOSTON

AXEL A. HOFGREN
ERNEST A. WEGNER
JOHN REX ALLEN
WILLIAM J. STELLMAN
JOHN B. McCORD
BRADFORD WILES
JAMES C. WOOD
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CHARLES L. ROWE
JAMES R. SWEENEY
W. E. RECKTENWALD
J. R. STAPLETON

WILLIAM R. McNAIR
JOHN P. MILNAMOW
DILLIS V. ALLEN
W. A. VAN SANTEN, JR.
JOHN R. HOFFMAN

LAW OFFICES
HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD
20 NORTH WACKER DRIVE
CHICAGO 60606

TELEPHONE
FINANCIAL 6-1630
AREA CODE 312

December 14, 1967

VIA AIR MAIL

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

Dear Bob:

I would like to report on the conversation I have just had with Judge Hoffman's clerk. I inquired regarding the possibility of going to trial on Monday, and he said "Don't bring in no witnesses." I asked about Tuesday, and he declined to comment.

The antitrust case was put over to the 21st.

I will call you shortly after our appearance on Monday to let you know what happened.

How is Prof. Chu?

Very truly yours,

Dale

Richard S. Phillips

RSP:iag

LAW OFFICES
HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD
20 NORTH WACKER DRIVE
CHICAGO 60606

TELEPHONE
FINANCIAL 6-1630
AREA CODE 312

December 21, 1967

VIA AIR MAIL

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

* Enclosed is a draft of an affidavit which I have not yet read. I will call you Friday morning for your suggestions. The motion will be simple and ask that the case be reset for February 13.

Very truly yours,

Richard S. Phillips

Richard S. Phillips

RSP:iag

* Enclosure

In the

United States Court of Appeals

For the Eighth Circuit

No. 19,000
Civil

UNIVERSITY OF ILLINOIS FOUNDATION,
Appellant,

vs.

WINEGARD COMPANY,
Appellee.

APPEAL FROM THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF IOWA,
DAVENPORT DIVISION.

APPELLEE'S BRIEF.

KEITH J. KULIE,
DONALD B. SOUTHARD,
135 South LaSalle Street,
Chicago, Illinois 60603,
312 CE 6-3351,
Attorneys for Appellee.

Of Counsel:
BURMEISTER, KULIE, SOUTHARD & GODULA,
135 South LaSalle Street,
Chicago, Illinois 60603,

EDWARD DAILEY,
DAILEY, DAILEY, RUTHER & BAUER,
National Bank Building,
Burlington, Iowa.

THE GUNTHORP-WARREN PRINTING COMPANY, CHICAGO

in the form of expert testimony and testimony of other witnesses, and the credibility of witnesses in resolution of conflicts of testimony, it is within the proper province of the trial court to make an initial determination of any of these issues.

In view of the fact that neither the opinion of the Court below or the brief of appellant refer to these other issues we will not burden this Court with further comment.

CONCLUSION.

The Court below properly and correctly assessed the prior art and made detailed findings of its assessment. The Court below applied the correct standard of invention in determining that the Isbell antenna structure was obvious to one having ordinary skill in the art in light of the findings that the court made of the state of the prior art. Additionally, the findings of the Court below are supported by substantial evidence and in no event can they be considered clearly erroneous.

The decision of the Court below is correct in every respect and we respectfully submit that it should be affirmed by this Court.

Respectfully submitted,

Keith J. Kulie,
Donald B. Southard,
135 South LaSalle Street,
Chicago, Illinois 60603,
312 CE 6-3351,
Attorneys for Appellee.

Of Counsel:
Burmeister, Kulie, Southard & Godula,
135 South LaSalle Street,
Chicago, Illinois 60603,

Edward Dailey,
Dailey, Dailey, Ruther & Bauer,
National Bank Building,
Burlington, Iowa.

closure involved nothing more than the work of an individual exercising ordinary skill in the art.

This represents a factual issue which may not be overturned on review unless clearly erroneous. Whether an improvement involves mere skill of one in the art or involves exercise of facility of invention is a question of fact and a finding either way upon that question by the trial court is conclusive on appeal unless clearly erroneous. *Rota-Carb Corp.* v. *Frye Mfg. Co.*, 313 Fed. 2d 443 (8th Cir. 1963). When a trial court in a patent case has followed the proper standards in determining the question of presence or absence of patentable invention, its finding upon that issue, if sustained by the evidence will not be disturbed on appeal. *Rota-Carb,* Id.

OTHER ISSUES.

We point out to this Court that there are other significant issues relating to the invalidity of the patent here in suit that were before the Court below but not specifically commented upon in its opinion. These issues involve publication of the subject matter of the invention more than one year before the application date; statutory bars which exist as to some claims by reason of late claiming; indefiniteness as to specific recitation in the claims; failure to recite essential matter in other claims; claim subject matter not supported by the specification; the defense of file wrapper estoppel; and still others.

We submit that it is settled law that a matter not disposed of in the District Court is not before the Appellate Court of Review, *Bergin* v. *Kiron State Bank,* 145 F. 2d 189 (8th Cir. 1944); and particularly so where the record on appeal in an incomplete state thereon, *Liken* v. *Shaffer,* 141 F. 2d 877 (8th Cir. 1944). Since the unresolved issues in the present case also involve a consideration of evidence

THE DECISION BELOW.

The Patent in Suit.

Judge Stephenson's statement of the subject matter involved in the patent in suit as it appears in his opinion (R 15-19) discusses the parameters of the Isbell patent in detail. Further comment is not required.

Prior Art.

The discussion of the prior art in the memorandum opinion accurately reflects the state of the art as of May 3, 1960, *the filing date of the Isbell patent in suit.*

The findings of the Court below include detailed recitation of the various aspects and elements of each of the prior art references and, we submit, clearly illustrate a thorough grasp and understanding of the substance of the references of the kind necessary for proper application of the standards for determining patentability.

Furthermore, the findings of the Court below, as noted elsewhere in this brief, are clearly supported in the record below not only by substantial evidence but by a clear preponderance of the evidence. The evidence upon which the court relied in making its findings and arriving at its decision included extended testimony of expert witnesses as well as other witnesses skilled in the technical learning and those witnesses concerning pertinent factual matters in addition to extensive documentary evidence, models and other physical exhibits.

The Invalidity of the Isbell Patent.

In arriving at the decision of invalidity of the Isbell patent the Court below applied the correct statutory standards *to conclude that the subject matter of the Isbell dis-*

INDEX.

patents in suit as prior art references of record.' This, says the appellant, is not of real consequence, because W. B. Wilbur was the Patent Office Examiner who handled the '938 patent, the original Walker patent application on which '938 was based and the McIntyre patent application which resulted in the McIntyre '955 patent. * * * Thus, says the appellant, he must have known of all prior art.[12]

"(Footnote 12: Appellant states no particular law is necessary to support this position. We do not agree. The examiner's mind, concerned with many patent prosecutions over a substantial period of time, is no more infallible than a judge's or a trial attorney's. The former cannot remember with certainty, in an opinion on one subject, all the positions he has taken in other cases involving the same legal principles, nor all the cases he has relied on to support his position. Nor can the average attorney, once having finished a case, remember all the cases he cited or considered in a previous case when preparing a new one.)"

We believe the above quotation from *Monroe* to be a realistic and proper statement of a real-life situation. We know only that there is no indication in the present record that either the DuHamel and Ore article or the Channel Master K. O. references in evidence in this case were considered by the Patent Office. We know further that neither was cited as a reference in the File Wrapper of the Isbell Application. We cannot comment beyond the record in this case because we then enter the "make believe" world.

the dimensions of the actual lengths and spacings of the various dipoles indicated in detail, the scale factors exhibited by the antenna cannot be derived and thus the full impact of the K. O. antenna as prior art not appreciated.

Since the Channel Master K. O. antenna was not before the Patent Office during prosecution of the Isbell patent (which appellant apparently recognizes by its later argument in the brief) appellant attempts to suggest that a "K. O." brochure was before the examiner during prosecution of another application in the Patent Office, ergo, this brochure was within the knowledge of the Patent Office examiner (page 28). Professor Mayes testified that he recognized a brochure describing the K. O. antenna as one that was brought to the attention of the examiner during prosecution of another patent application (PX 66) and by curious syllogistic reasoning arrives at the non-sequitur that it must have been within the knowledge of the examiner in the Isbell application.

The Court below did not have the benefit of testimony from the one source that could have established the fact of this knowledge—the Patent Office Examiner. Since this testimony generally is not available in any instance, a substitute inference could have been shown if the reference had been cited in the printed Isbell patent or in the file wrapper—it was not, as the Court below correctly observed.

This laborious contention to show that the examiner considered certain prior art was involved in *Monroe Auto Equipment Company* v. *Superior Industries, Inc.*, 332 F. 2d 473 (9th Cir. 1964), where three separate patents were involved and all were examined by the same person. The court stated:

> "The district court, says appellant, was apparently misled in this issue, 'because the prior art patents relied on by defendant are not listed at the back of the

AUTHORITIES CITED.

We do not understand why appellant elected not to place the domuments referred to in PX 68 in evidence during its presentation of the case but we believe that neither we or this Court can be called upon to answer that question. The introduction of this material into evidence would have been very simple—requiring only the offer of a certified copy of the complete interference record in this case. For some reason appellant elected to keep this material out of the trial and we can only speculate as to the basis for that decision.

Accordingly, neither the DuHamel and Ore article considered by the Court below or the Channel Master K. O. document considered by the Court below are shown to be those which in any way were before the Patent Office. The court was considering these materials for the first time and the presumption of validity in weakened in exactly the way stated by the Court in its decision.

Even if we were to consider the statements by the University of Illinois Foundation to be true the fact is that the actual Channel Master K. O. antenna still was not before the examiner at the time of his review of the Isbell patent. There was never any suggestion of this and the only statement that the Foundation offers now is that the structure was before the Office in the form of a disclosure in a document. Unfortunately, that document is not before the Court so we are unable to determine whether it discusses the antenna that was physically before the Court. In view of the appeal that visual exhibits have over the written word, we think that the inference intended by appellant cannot be supported. An actual K. O. antenna was before the Court below (the Channel Master K. O. antenna) that was never considered by the Patent Office at any time during prosecution of Isbell patent. Without the actual physical model being present, or having all of *is not in the record before this Court.* The document referred to in PX 68 (R 175) relates to an IRE National Convention Record whereas DX A-1 referred to by appellant is a publication of the Research and Development Division of Collins Radio Company. The two documents may or may not be the same—we do not know. However, the Court below did not have the benefit of a review of the reference that was before the Patent Office and could not consider that reference in arriving at its decision in this case.

Appellee did not have an opportunity to examine as to that document below. We do not believe that we have the burden here of acknowledging or disavowing anything that is not in the record in this case. We can only comment, in conclusion, that the reference before the examiner, whatever it included, was not before the Court below and there is no basis in the record for the statement made now by appellant that DX A-1 was the reference before the examiner.

Appellant further attempts to cast doubt upon the decision of the Court below in its consideration of the K. O. antenna in stating:

> "The trial Court also failed to take into consideration the fact that although the K. O. antenna as a physical exhibit was not before the Patent Office, a full disclosure of its structure was considered in connection with the prosecution of the Isbell patent (R 176)."

We submit that appellant's statement, rather than any finding of the Court below, is clearly erroneous. The reference alluded to by appellant is identified as DX B-4 (R 197), an exhibit placed in evidence by appellee. However, there is nothing in the record to show that this exhibit is or is not the same as the document referred to in the Patent Office interference motion (PX 68).

In the

United States Court of Appeals

For the Eighth Circuit

No. 19,000
Civil

UNIVERSITY OF ILLINOIS FOUNDATION,
Appellant,

vs.

WINEGARD COMPANY,
Appellee.

APPEAL FROM THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF IOWA,
DAVENPORT DIVISION.

APPELLEE'S BRIEF.

I.

STATEMENT OF FACTS.

A. BACKGROUND.

Initially, appellee is compelled to correct numerous inaccuracies and misstatements in appellant's "Statement of the Facts" in its brief. In some instances such inaccuracies are in the form of half-truths and others are misleading or misrepresentative.

Appellant, in the "background" section of its brief, has assumed the task of educating this Court in the fundamentals of antennas, particularly with respect to television antennas. After a review of this material we are left with a clear and definite impression that appellant is far more interested in setting up "straw men" than in providing an objective dissertation of the art of antenna design.

For example, appellant states that uniformity of gain across the band is an important factor in a television antenna and then asserts that the "patented antennas" are characterized by uniform gain across the entire band of operation. Both statements are half-truths. Mr. John Winegard pointed out with particularity that the typical television antenna, rather than having strictly uniform gain across the band of operation, should exhibit a slightly rising gain characteristic (SR 47-48).* Further, as stated by Dr. Yang, the log-periodic antenna has a characteristic wherein the energy or power capture area actually *decreases* with an increase in frequency (SR 80). This is certainly opposed to the characteristic that appellant states is required. Even appellant's own expert witness, Mr. Harris, on rebuttal examination stated, without reservation, that an antenna made according to the Isbell patent teaching did not have one of the design criteria necessary for an antenna he would design for television operation, namely, a rising gain characteristic and, accordingly, he would modify it to improve the gain characteristics so that it would be slightly rising (SR 85).

We also wish to point out to this Court that there were a great many television antennas in the art prior to the development of the subject matter described in the Isbell

* Each reference to the Supplemental Record in this brief shall be prefaced by the letters "SR" and reference to the printed record accompanying appellant's brief by the letter "R".

of whether the Isbell patent is valid in light of the prior art. The Court considered references presented to it, whether they were previously considered by the Patent Office or not, and based upon its study of the references decided that Isbell did not make a patentable invention.

However, appellant argues that the presumption of the Isbell patent was "great" in view of the alleged fact that the Patent Office considered the "principal" references relied upon by the Court. We disagree.

However, the decision of the Court below correctly noted that, among the references relied upon by appellee to show the prior art at the time of the purported Isbell invention were (1) four prior patents cited by the examiner in the patent; (2) five patents not cited by the examiner; (3) an article published on March 31, 1958; and (4) three antennas in use prior to 1959 (R 19).

The decision below specifically discusses the Katzin patent (cited in the Isbell patent); the Channel Master K. O. antenna (which was not before the Patent Office); the Koomans patent (which was not before the examiner); the Winegard patent (which was not before the examiner); the White patent (which was not before the examiner) and a DuHamel and Ore article (which was not shown to have been before the examiner—the reference noted by appellant not being in evidence in this case).

Appellee submits that the Court below never "recognized that the DuHamel-Ore publication (DX A-1) had also been before the Patent Office, * * *" as suggested in appellant's brief. The amendment to footnote 14 of the decision below does not support appellant's statement. But, rather than have this Court consider that we are playing games with words in this respect we can affirmatively assert that the DuHamel-Ore publication alluded to by appellant *was not placed in evidence during the trial and*

Manufacturing Co. v. *Wen Products, Inc.*, 231 F. 2d 795 (7th Cir. 1956) wherein Judge Lindley speaking for the court said:

> "* * * inasmuch as Judge Barnes had before him in a 9 days' trial, the extended controversial testimony of expert witnesses on behalf of the respective parties, as well as that of the patentee, certain witnesses skilled in technical learning and other witnesses concerning certain pertinent factual matters, in addition to extensive documentary evidence, models and other physical exhibits, the rule we announced in *Hazeltine Research, Inc.* v. *Admiral Corp.*, 183 F. 2d 953, cert. denied 340 U. S. 896, is applicable to the present situation. In other words, just as, in that case, we felt that in view of the conflicting testimony of expert witnesses and other controversial testimony, we were not at liberty to deny the applicability of Rule 52(a) of the Federal Rules of Civil Procedure, 28 U. S. C., so here, after an examination of the record and consideration of the conflicts between the witnesses, we have no right, we think to redetermine the findings of fact of the District Court or to say, as a matter of law, that they are clearly erroneous. *The circumstances of this case take the issue out of that category of decisions where the evidence consists entirely of documentary evidence, such as* * * * (citations omitted)." (Emphasis added.)

For all practical purposes, the court in *Weller* could just as well be referring to the present case.

THE PRINCIPAL REFERENCES RELIED UPON BY THE LOWER COURT IN HOLDING ISBELL INVALID WERE NOT SHOWN TO BE BEFORE THE PATENT OFFICE DURING PROSECUTION OF THE ISBELL PATENT AND THE PRESUMPTION OF VALIDITY IS WEAKENED AS CORRECTLY STATED BY THE COURT BELOW.

We suggest that we are not faced with the issue of the "presumption of validity" here but rather with the correctness of the decision of the Court below on the issue

patent which exhibited a uniform or slightly rising gain characteristic across the VHF television frequency band. For example, the Channel Master K. O. antenna (DX J-6, J-6a) and the Color 'Ceptor antenna (DX L-15; DX C-8), to name but two (SR 90, 93).

Appellant states (page 5)** that it is an advantage that a television antenna have unidirectional directivity and be capable of receiving signals equally well over a wide band of frequencies. We agree. Appellant then asserts that the "antennas of the patent in suit" have these desirable properties. What appellant does not advise the Court is that these characteristics also are common to all of the antennas cited as prior art in the present suit. With the exception of the single channel Yagi antennas and those specifically designed for only one or two channel operation, these characteristics are common to practically *all* television antennas prior to the development of the subject matter of the patent in suit (SR 52-55). Appellant obviously is far more interested in establishing "straw men" which it can conveniently destroy. This may be common practice in ex parte practice but not in an advocacy proceeding.

Appellant also contends (page 5) that at the time of the assignment of TV channel frequencies immediately after World War II, there were no satisfactory receiving antennas for television because there was no available antenna design to cover such a broad range of frequencies. First, we point out to the Court that it is not the state of the art immediately subsequent to World War II (1945) that concerns us here but the state of the art immediately prior to the development of the subject matter disclosed in the Isbell patent in suit, that is, in the late fifties. Moreover, the Winegard Company has actively been designing

** References to page numbers will in each instance be to appellant's brief.

and producing antennas suitable for television reception since its inception in early 1954. Presently, the design and manufacture of television antennas comprises approximately 70% of the business of the Winegard Company (SR 35). Mr. Winegard testified at length concerning the numerous antennas designed by him. Mr. Winegard recalled that the first antenna designed by him was in 1949 and was a broadside coplanar array with eight driven elements (SR 36). In 1950 or 1951, a broadband Yagi array was designed by Mr. Winegard for coverage of channels 4 and 5 (SR 36). As early as 1952 Mr. Winegard, while a partner in Wells-Winegard Company, designed an all-VHF television antenna for coverage of television channels 2 through 13 having compound driven elements and transposed phasing lines (SR 39). Mr. Winegard also testified that he has not encountered a problem in designing an antenna with good performance characteristics covering either of the two VHF bands since 1954 (SR 62-63). Since that time the Winegard Company has developed and manufactured hundreds of antenna models. The antenna which has established the largest sales volume is the Color 'Ceptor model (DX L-15; C-8) developed in 1956 (SR 45, 72). This antenna possesses every characteristic which appellant has stated to be desirable for a television antenna, including low VSWR, broad-band, high gain, etc. (SR 45, 46).

Appellant asserts (page 7) that "compromise" antenna designs were used for the VHF television channels which, while satisfactory for black and white television reception, were not adequate for color television reception. We are not enlightened as to the specific time period to which appellant refers. In any event, we submit that this contention is misleading. Mr. Winegard specifically testified that the Winegard Company has never made a television antenna that was not suitable for color television reception (SR 50).

> acteristics of the patented structure and the accused device, are deprived of the degree of finality which would otherwise attach under Rule 52(a) of the Federal Rules of Civil Procedure. We are in as good a position as the trial court to examine and evaluate the evidence and make the necessary determinations ourselves."

The foregoing quote from the *Nasco, Inc.,* case, however, is taken out of context of the case and, we submit, represents a significant misrepresentation of the court's ruling. Appellant has deleted a highly significant sentence immediately preceding the quoted portion. The passage in question states as follows:

> "*The defendant offered no testimony, expert or otherwise, on the prior patent art.* The appealed decision rests entirely on documentary evidence and physical exhibits. Consequently, * * *." (Emphasis added.)

This is an entirely different meaning from that suggested by Appellant's quote of the case. In the instant controversy, the trial required an entire week, with appellee calling eight separate witnesses in its behalf and which, together with the appellant's witnesses, resulted in over seven hundred pages of testimony. Much of this testimony relates precisely to the state of the prior art, including the prior art patents and physical antenna structures.

We submit that it is a well established principle of law, for patent cases as well as any other, that due allowance must be made for advantages possessed by the lower court in resolving conflicting testimony and that an appellate court cannot simply substitute its judgment for that of the lower court and set aside findings of fact in the absence of a showing that they were clearly erroneous. *Hyster Co.* v. *Hunt Foods, Inc.,* 263 F. 2d 130 (7th Cir. 1959).

The underlying principle is more aptly stated in *Weller* resolved by comparing a prior patent with a later patent to ascertain whether the teachings of the former were repeated in the latter, and this involved a simple examination of two legal documents to determine whether they are or they are not the same. With respect to the question of obviousness, however, this court in *American Infra-Red Radiant* pointed out that it was not unmindful of the rule set out in *Rota-Carb Corp.* v. *Frye Manufacturing Co.*, 313 F. 2d 443 (8th Cir. 1963) that the issue of whether an improvement constitutes mere mechanical skill or involves the exercise of invention is a question of fact which is conclusive, unless clearly erroneous.

Appellant also cites the case of *State Farm Mutual Automobile Ins. Co.* v. *Bonacci*, 111 F. 2d 412 (8th Cir. 1940) in support of its contention. We are unable to find such support in the cited case. On page 415 of the opinion, the court there states:

> "The facts largely relied upon in this case consist of testimony and written statements given or made by the defendants *not in the presence of the lower court* but in the course of the trial of the damage actions in the state court. The lower court, as to such evidence, had no better opportunity of judging the credibility of the witnesses than does the appellate court." (Emphasis added.)

Such factual circumstance is hardly relevant to that of the instant case.

Even more significant is the case of *Nasco, Inc.* v. *Vision Wrap, Inc.*, 352 F. 2d 905 (7th Cir. 1965), cited by Appellant as having particular application in patent cases. Appellant quotes the following from the court's opinion:

> "The appealed decision rests entirely on documentary evidence and physical exhibits. Consequently, the court's findings, in so far as they concern the use made of prior art, the nature of the improvement made over the prior art, and the operational functions and char-

B. THE PATENT IN SUIT.

It is interesting to note appellant's description of the so-called "cell" (page 8), and that an antenna according to the Isbell teaching comprises a plurality of repeating design cells (citing testimony by appellant's witness, Mr. Harris). Appellant relies upon the Harris testimony for the contention that the design cell, according to the Isbell teaching, is a straight dipole plus an adjacent section of transmission line with transposed conductors. A sketch is included (page 8) to illustrate this alleged definition.

In the first instance, Harris does not refer in his testimony to the "cell" of the Isbell patent as a *straight* dipole plus *and adjacent section of transmission line with transposed conductors,* as suggested in the brief. He refers to it simply as a transmission line and the dipole in the Isbell antenna (R 92). Harris does not refer to such definition as being found anywhere in the Isbell disclosure. Indeed, he could not, because no reference is made anywhere in the Isbell disclosure for this mysterious "cell" term. The drawing Mr. Harris referred to in his testimony was not the patent drawing but rather to one he sketched in chalk on a blackboard and which was not preserved.

The "cell" concept was first introduced into the Isbell application in claims 13, 14 and 15, some five years after the filing date of the application which culminated in issuance of the patent in suit. The "cell" concept was never discussed prior to this time and does not appear anywhere in the application materials as filed.

We may take it that Mr. Harris' testimony represents but one opinion of what the "cell" concept may involve. Claims 14 and 15 of the Isbell disclosure, however, refer to the "cell" as:

> "* * * a dipole and the feeder between it and the adjacent dipole * * * the dimension of the several

cells measured from the point of connection of one dipole and the feeder to the outer end of the next smaller adjacent dipole."

This is the one and only reference in the patent to the term "cell" and thus constitutes the full extent of the teaching for that term. From the language that is present in these two claims a number of different interpretations can be given. Some representations of these various interpretations are set forth in the chart, Appendix A, attached to this brief. Only six of the possible interpretations of the claim language in question are shown in Figures A through F, Appendix A, although it is to be understood that others exist.

Appellant departs at this point from a discussion of the patent in suit (page 9) and becomes involved in reference, presumably, to an antenna structure that is other than that of the patent. For example, it is alleged that the antenna of the Isbell patent has provided a unique solution to the problem of wide band television reception, particularly of color television signals. This was not a problem at the time of Isbell's activity. The record is replete with references to antenna structures that existed prior to Isbell which not only were commercially significant but which were well suited for reception of color television signals over the entire VHF television band.

The antenna of the Isbell teaching has serious design limitations with respect to requirements for television reception, either black and white or color. Dr. Yang, as an experienced antenna design engineer, stated that the Isbell antenna was not desirable for television reception in view of its inherent inability to provide a constant energy or power capture area. That is, less energy is received in an antenna in accordance with the Isbell disclosure as the frequency is increased (SR 80).

standard of invention in concluding that the Isbell development would have been obvious to a person having ordinary skill in the antenna design art when considering the Isbell development in light of its findings on the prior art. This is what we read from the decision of the Court below.

Appellant now arbitrarily suggests to this Court that the Court below did not do this but used some other test. We do not find any other test set forth in the opinion of the Court and submit that this is conjecture on the part of appellant and the typical illusion of a frustrated patentee.

THE FINDINGS OF THE TRIAL COURT ARE SUPPORTED BY SUBSTANTIAL EVIDENCE, ARE BASED UPON A CONSIDERATION OF TESTIMONY OF EXPERT AND OTHER WITNESSES, PHYSICAL EXHIBITS AND OTHER EVIDENCE AND CANNOT BE CHANGED UNLESS FOUND TO BE CLEARLY ERRONEOUS.

Appellant contends the trial court reached its decision by relying solely on documentary evidence and physical evidence which this court is in as good a position to consider as the trial court. We are not enlightened as to how appellant divines the trial court relied solely on documentary evidence and expressly rejected the testimony of the several expert witnesses and others in making its findings. How Appellant can look into the mind of the Court below to conclude that only certain evidence formed the basis for its decision from all of the evidence of record is quite remarkable. We are unable to do this.

In any event, Appellant cites three cases evidently for what it contends is the "so-called 'documentry' rule." In *American Infra-Red Radiant Co.* v. *Lambert Industries, Inc.*, 360 F. 2d 977, 988 (8th Cir. 1966) case, the court was looking to the issue of "novelty" as set out in 35 U. S. C. 102(a), not the question of obviousness under section 103. The court there stated that the issue (novelty) had been

WHITE PATENT 2,105,569.

For some reason, appellant chooses not to discuss the White Patent, although it was discussed in the opinion of the court below in connection with determining the state of the art at the time of the Isbell application filing date. The Court below correctly stated that the White Patent discloses the use of transposed feeder lines in conjunction with dipole elements which decrease in length from one end of the array to the other (R 21). The Court further observed that the White array was "center-fed", rather than the series feed of the other prior art patents and structures.

Dr. Yang discussed at length the White disclosure. He observed that the lumped impedances in the feeder lines had nothing to do with the phasing (R 132) but were for fine adjustment only with no substantial influence on the radiation pattern (R 133). When asked whether an antenna engineer could design a television antenna according to the White patent for channels 2 through 6, Dr. Yang's answer was in the affirmative.

The Court will note that the White patent states that with the structure (as therein disclosed) the polar diagram is substantially independent of frequency over a substantial range of side band frequencies (White, page 2, col. 2, lines 14-17; R 212).

THE COURT BELOW DID NOT USE HINDSIGHT IN DETERMINING THE ISSUE.

We are not confident that we understand the basis for appellant's contention that the Court below used "hindsight" in determining the Isbell patent to be invalid. The Court made detailed findings as to the nature and extent of the prior art in evidence and then applied the correct

Appellant also would have this Court believe that Isbell was the first to provide an antenna for television reception over the entire television band which required but a single transmission line between the antenna and the television set. This is an incredibly naive statement and is a misrepresentation of the actual fact situation that existed in the television antenna industry prior to Isbell. The fact is that every antenna of record in this case has only a single transmission line between the antenna and the television set.

It might be well at this point to review what Isbell did *not* originate to permit a more accurate appreciation of the state of the art. In summary:

1. Isbell was not the originator of frequency independent antennas;
2. Isbell was not the originator of that class of antennas commonly referred to as "log-periodic" antennas;
3. Isbell did not develop the mathematical formulae to be applied to dipole length and spacing to obtain the geometrical progression in the dimensions thereof;
4. Isbell was not the first to use a plurality of dipole elements in an antenna array;
5. Isbell was not the first to employ linear dipoles in an antenna array;
6. Isbell was not the first to use a transposed feeder line between dipole elements;
7. Isbell was not the first to use a transposed feeder line with the antenna being fed from the front for endfire or backfire operation;
8. Isbell was not the first to use "stagger-tuning" for a multiple dipole element array across a given bandwidth so as to result in the lengths of the dipole elements varying progressively according to a substantially constant scale factor;
9. Isbell was not the first to use a single transmission line extending from the antenna to the set in an antenna having a plurality of elements in the array.

STATEMENTS OF POINTS TO BE ARGUED AND OF AUTHORITIES.

1. The appropriate standard of invention to be applied in this case is whether the Isbell development, as a whole, was obvious at the time the subject matter was developed to a person having ordinary skill in the art of designing antennas. This standard in no way hinges upon whether one can predict the functional aspects of the particular subject matter. The standard of invention does not change in application to different fields of invention. 35 U. S. C. 103; *Fairchild* v. *Poe,* 259 F. 2d 329; *Rota-Carb Corp.* v. *Frye Mfg. Co.,* 313 F. 2d 443; *Graham* v. *Deere,* 383 U. S. 1.

2. Under 35 U. S. C. 103 it is not necessary that all of the elements of the combination be found in a single earlier reference. The issue under Section 103 is whether the subject matter as a whole would have been obvious to one skilled in the art in view of the state of the art as we are able to glean it from the references cited. *All* of the references may be used to show what the art knew, and in that sense "combined." *Fairchild* v. *Poe,* 259 F. 2d 329; *In re Adams,* 356 F. 2d 998; 35 U. S. C. 103.

3. The findings of the trial court are based upon substantial evidence and are conclusive unless shown to be clearly erroneous. The issue of obviousness is an issue of fact subject to findings by the Court below and when based upon substantial evidence are subject to Rule 52(a). *Rota-Carb Corp.* v. *Frye Mfg. Co.,* 313 F. 2d 443; *Weller Mfg. Co.* v. *Wen Products, Inc.,* 231 F. 2d 795; *Hazeltine Research, Inc.* v. *Admiral Corp.,* 183 F. 2d 953; *Hyster Co.* v. *Hunt Foods, Inc.,* 263 F. 2d 130.

4. Where there is extensive testimony of expert and

dipole configuration and where the dipole elements had been split and the top section of the two bar element folded back along the boom of the antenna. Of course, Mr. Passer would state that Channel Master had never made or sold a mutilated antenna of this kind. Mr. Passer was never examined as to whether Channel Master had ever sold the K. O. type antenna with simple dipoles vis-a-vis folded dipoles and thus record is devoid of support for appellant's contention on this point.

WINEGARD PATENT 2,700,105; KOOMANS PATENT 1,964,189.

Appellant dismisses the Winegard and Koomans patents for the wrong reasons. It is stated that since they do not relate to log-periodic structures they cannot be pertinent references. Moreover, appellant states that Koomans is a broadside array rather than an endfire array and for this reason not applicable. However, on cross-examination, Dr. Mayes was asked:

> "Q. Dr. Mayes, was it not well known before 1959 that if the doublets of the Koomans patent were spaced distinctly less than a ½ wave length apart the principal radiation would not be perpendicular to the array plane but would be parallel to that plane?"

Dr. Mayes answered in the affirmative meaning that prior to Isbell all the knowledge existed in the art to make the Koomans antenna array and endfire array and appellant's reason for rejecting the Koomans reference disappears.

Also, both the Koomans and Winegard references were cited and noted by the Court below to be pertinent for their teaching of the use of transposed feed lines between driven elements.

not controverted by appellant. The record is abundantly clear that, with the exception of a slight difference in characteristic impedance, there is an equivalency of operation between folded dipoles vis-a-vis simple dipoles for antennas operating within the VHF television band range. During cross examination by counsel for appellant, Dr. Yang stated that the radiation pattern of an antenna is of first concern and that any difference in impedance can always be matched in some other way without involving radiation (SR 82). As far as radiation pattern is concerned Dr. Yang stated that he could see no difference between simple or folded dipoles. Also, Mr. Winegard testified that he sees no difference between folded and simple dipoles other than a slight difference in impedance characteristics and that he had used the two interchangeably in many instances in his activity at the Winegard Company without observable effect (SR 49-51).

Even more conclusive than the statements by the expert witnesses in this case are the test data introduced into evidence by appellee and not controverted in any way by appellant (DX K-1-A(1-6); DX K-1-B(1-6); SR 131-142). These data conclusively illustrate that, with the exception of an expected difference in characteristic impedance, the K. O. antenna exhibits essentially the same operational characteristics with folded dipoles as with simple or linear dipoles. The data show that there basically is no difference in measured band width, gain, directivity and front to back ratio (SR 56-58).

Appellant finally notes that the substitution of simple for folded dipoles is unobvious because it was never done and refers to the testimony of Mr. Passer (R 127, 128) in support of this statement. First, we point out that the statement made here by appellant is wholly gratuitous and has no support in the record. Mr. Passer was being examined as to an antenna that originally had a folded

other witnesses and conflict of testimony and credibility evaluations to be made as well as physical exhibits and other evidence of record before the Court, it cannot be said that the findings are based solely upon documentary evidence. *Hyster* v. *Hunt Foods,* 263 F. 2d 130; *Weller Mfg. Co.* v. *Wen Products Co., Inc.,* 231 F. 2d 795; *Hazeltine Research, Inc.* v. *Admiral Corp.,* 183 F. 2d 953, cert. den. 340 U. S. 896.

5. The DuHamel-Ore article and the Channel Master K. O. antenna references relied upon by the lower Court in holding the Isbell patent to be invalid were not before the Patent Office during prosecution of Isbell. The presumption of validity is weakened when references considered by the Court were not before the Patent Office. A reference noted in some other Patent Office proceeding cannot be said to have been considered by the examiner notwithstanding that this examiner may have been involved in the other proceeding. *Monroe Auto Equipment Co.* v. *Superior Industries, Inc.,* 332 F. 2d 473.

ARGUMENT.

THE PRIOR ART IN RELATION TO THE ISBELL DEVELOPMENT.

Appellant sets forth three conditions to support its contention that the Isbell invention was not obvious. Briefly, these are:

(1) An alleged unpredictability of the effect of operation of elements in the electronics field;

(2) An inability to predict whether any given log-periodic design will provide frequency independent operation;

(3) Lack of a basis for combining prior art references.

With respect to the first contention, we submit that it departs from the express provisions of the patent law which requires that any development to involve a patentable invention must be new and useful (35 U. S. C. 101) and must be unobvious to a person having ordinary skill in the art (35 U. S. C. 103). We are not aware of any different standard of invention to be applied with respect to developments in the mechanical field, electrical field or in the chemical field. Appellant is apparently suggesting that a different standard of invention applies to any development in the electrical and chemical fields. We submit that this is not the stated intent of the patent law and appellant has cited no cases which would support this new theory.

Any antenna design engineer having ordinary skill in antenna design would know that a dipole will exhibit maximum response to a frequency which is a multiple of a quarter wave length. Any antenna designer would know

The scale factor for dipole spacing has been stated by Mr. Harris as being the least significant of any of the design factors of the Isbell patent. During examination Mr. Harris stated (SR 18-19):

> "Q. Now, again, going into these various tau factors, you have already testified that there is a tau for the length of the element, a tau which you have calculated for the cell aspect of the element or of the antenna, and a tau for spacing. Now, in connection with these various taus, Mr. Harris, do they have any relative importance, each to the other, with respect to the operation and performance of log-periodic frequency independent antennas?
>
> A. Yes. In order of importance, the dipole lengths is the most important factor in the performance of the antenna, and the tau for the dipole therefore would be the most significant figure. The next most significant figure, the next most important consideration, would be the tau for the cell and the least important is the tau for spacing.
>
> Q. So then, taking into consideration an antenna design where the tau factor for length and the tau factor for cell were substantially constant and both less than one, what would be the effect of having a tau constant for spacing which was 1?
>
> A. It would be a second order effect. It would be a minor effect on a performance of the antenna."

By appellant's own test, then, the K. O. antenna responds to the Isbell teaching. Nevertheless, appellant contends that the K. O. antenna cannot be used as a reference against the Isbell patent in this case. This is a familiar contention. It was made consistently in pre-trial memoranda, during the trial and in post trial briefs. The Court below was fully exposed to the contention made by appellant in this regard and must be regarded as having rejected it in view of the showing made by appellee and by test data introduced into evidence by appellee, which test data was

K. O. ANTENNA.

Appellant states that the "K. O. antenna, although consisting of an array of more than three *folded* dipoles interconnected by transposed transmission lines, is actually evidence of the invention made by Isbell." If this statement means that the K. O. antenna anticipates the subject matter of the Isbell patent, we agree. It is one of the better physical representations of the Isbell-type structure.

Appellant proposes to discard the K.O. reference on the basis that it uses folded dipoles and that they are not arranged in accordance with a scaling factor for dipole spacing or "cell" dimensions. We note, with significance, that appellant conveniently ignores the separate scaling factor for lengths at this point even though it has included separate reference to the scaling factor for dipole spacing.

As pointed out to the Court below, a review of the dimensions of the K.O. antenna show scale factors for the respective dipole lengths, starting with the rear or longest dipole elements, as follows:

0.94, 0.90, 0.91, 0.90 and 0.90.

This represents a variation in the scale factor between the longest dipole elements and the next longest dipole elements of approximately 4%. The variation of the scale factor between the remaining dipoles is, or for all practical purposes, precisely zero.

The so-called "cell" scale factor, taken as defined by Plaintiff's witness, Mr. Harris, (for there is nothing in the Isbell patent to help us define "cell") show a numerical range of:

0.95, 0.93, 0.87 and 0.98 (Average 0.93).

The above noted length and "cell" scale factors are seen to correspond to the teaching of the Isbell patent.

the effect of using transposed phasing lines between multiple driven elements of an antenna. Any design engineer would know the effect of adding parasitic elements to an antenna array, such as directors and reflectors. Many more examples can be given of the extent of the knowledge of an antenna design engineer having ordinary skill in this art. However, they are unnecessary here. The fact is that antenna design engineers are skilled in the art of designing in his field of specialty. To hold otherwise would emasculate the provisions of 35 U. S. C. 103.

THE DESIGN OF A FREQUENCY INDEPENDENT LOG-PERIODIC ANTENNA IS NOT IN ISSUE.

Appellant states that the design of a specific frequency independent log-periodic antenna is not obvious. The real issue here is whether the Isbell antenna structure would have been obvious in light of the prior art to one having ordinary skill in the art at the time of Isbell's activity.

In support of this allegation it refers to excerpts from portions of Defendant's exhibits introduced during the trial alluding to an "unpredictability" with respect to frequency independent antennas. It is interesting to note that one of these exhibits (Jasik's Antenna Engineering Handbook, DX A-10b) points out how easily the Isbell antenna structure is derived from the prior art DuHamel structure (R 191).

In any event, the point that must be kept in mind is that we are concerned here only with whether the Isbell antenna structure would be obvious in light of the prior art teachings—not whether one could in every case predict whether any antenna structure would exhibit frequency independent characteristics. To answer the latter question we would have to exhaust all negative possibilities. We are not faced with that task here.

Appellant concludes this portion of its brief by reference to Professor Mayes' testimony (Page 15) suggesting that "even today, * * * it is still impossible to predict whether any given log periodic structure will function as a frequency independent log periodic antenna." Professor Mayes' testimony, however, conflicts with testimony of appellant's other expert witnesses here when, in classifying the accused Winegard Company antennas as frequency independent log-periodic antennas, his prediction was based only upon visual observation of the structure and the application of "generalized theory of log periodic antennas" (SR 22).

The remaining portion of appellants' arguments continuing on to page 15 of its brief relates primarily to whether you can always predict whether an antenna structure will exhibit frequency independent characteristics. Again, we note that this is not the issue here. We are concerned only with a determination of whether Isbell's antenna structure would be obvious to one skilled in the art and not whether one could predict all antenna structures that might exhibit frequency independent characteristics. We are not required to answer the latter question.

REFERENCES MAY PROPERLY BE COMBINED TO SHOW THE STATE OF THE ART PRIOR TO ISBELL'S DEVELOPMENT.

Appellant suggests in its argument beginning at the bottom of page 15 that you cannot combine prior art references to find that Isbell did not make an invention. This suggestion is completely opposite to the provision of 35 U. S. C. 103. One of the main aspects of the patent act of 1952 was the addition of section 103 to the patent law. The patent law after the passage of the 1952 act required that a development, to satisfy the requirements of patent-

KATZIN PATENT 2,192,532.

We fail to understand appellant's dilemma where it states that the Katzin patent lacks a teaching of how the dipoles should be arranged and interconnected for cooperative interaction (page 21). The court below correctly pointed out that the Katzin patent teaches the combination of dipoles of differing lengths combined into the array to provide a "more uniform response over the desired frequency spectrum" (Katzin, page 2, col. 1, lines 27-29; R 217). The Court below also noted that according to Katzin a group of elements of differing lengths combined into one array "will respond most efficiently to its corresponding band of frequencies, so that the combination of two or more such groups * * * will give the result of a high response for a wider frequency band." (R 20; Katzin page 2, col. 1, lines 16-21; R. 217).

Appellant would also have this Court understand that Katzin is not relevant because it teaches loose coupling of the dipole elements to the transmission line rather than direct coupling. However, as is clear from the record below, the Katzin patent specfically suggests that an alternatve method would be direct coupling of the dipole elements to the transmission line as pointed out in Katzin at page 2, col. 1, lines 50-55 (R 217). Appellant concludes its discussion of Katzin by contending that the Katzin antenna is "endfire" while the Isbell antenna is "backfire". Mr. Winegard, as an experienced antenna design engineer, has always considered any antenna having two or more dipoles connected together in a horizontal plane as an endfire antenna (SR 90). Thus, Appellant's "problems" with the Katzin patent as a reference are far more apparent than real.

THE LOWER COURT'S DECISION THAT ISBELL'S DEVELOPMENT OBVIOUS TO ONE HAVING ORDINARY SKILL IN THE ART IN VIEW OF THE PRIOR ART IS CORRECT.

Appellant in its "prior art" section of its brief (pp. 20-21), in effect, suggests an abolition of 35 U. S. C. 103. Appellant also states that, in any event, the three principal references relied upon by the Court below were "cited and considered by the Patent Office during the prosecution" of the Isbell patent. This is a misrepresentation of the fact situation proved to the Court below.

Initially, 35 U. S. C. 103 exists and recently was the subject of a significant decision in this circuit and in the Supreme Court of the United States. *Graham* v. *Deere,* 383 U. S. 1 (1966). Appellant's desire to ignore this statutory provision is understandable but opposed here.

As noted above, we are not required to consider separate "bits" of information as distinct entities. This practice would require that in every instance we find an exact anticipation of any development in a single prior art reference. We would not be permitted, according to the theory now suggested by appellant, to consider the state of the prior art if that art existed in more than a single prior reference.

We submit that appellant's contention is an erroneous representation of 35 U. S. C. 103. The Supreme Court of the United States has never suggested that this is the law. This Court does not interpret 35 U. S. C. 103 in this unique manner. We appreciate that a patentee may wish to have Section 103 interpreted in this manner but submit that the patent law is intended to shelter the public against unwarranted instrusion upon their lawful activity as well as to offer protection for limited periods to those who make patentable inventions. Appellant's contention of the nature of Section 103 is erroneous and should be rejected.

ability set out in the statute, not only had to be new and useful but also had to be unobvious to one having ordinary skill in the art.

Section 102 of the patent code is the only provision that requires complete anticipation in a single reference. Section 103 of the patent code expressly permits viewing the prior art on one hand and the alleged new development on the other to determine whether the differences that exist, if any, would be obvious in light of the state of the art to one having ordinary skill in the pertinent art.

We agree with appellant in its analogy of an automobile carburetor, charcoal burner, jet engine combination that it would not be reasonable to combine references from non-analogous arts. However, references in analogous arts have always been properly combined.

Under 35 U. S. C. 103 it is mandatory that each development be considered by the test set forth therein. It is not necessary that all of the elements of the combination be found in a single earlier patent or in a single device previously in general use and it is enough if the prior art taken as a whole discloses that all of the claimed elements are found in different prior patents in the art or in different devices previously in general use. *Fairchild* v. *Poe,* 259 F. 2d 329 (5th Cir. 1958).

Appellant states on page 16 of the brief that:

> "Contrary to the Supreme Court's recognition of the unpredictable nature of electronics, corroborated in this case with respect to the subject matter of Isbell's invention, the lower Court used the standard applicable especially to mechanical patents."

There is absolutely no support for appellant's contention that there is a different standard of invention for mechanical developments as compared to chemical or electronic developments.

There is no constitutional provision which makes the above distinction. We are not aware of a statutory provision which makes this distinction. We are not aware of case law which makes this distinction. There have been statements by some courts in a few instances, by way of dicta, suggesting that chemical and electrical developments, as well as some mechanical developments, are difficult for the court to understand but we submit that the standard of invention is the same for all developments regardless of the field of application.

It is not now and never has been clear what the expression "can be combined" is supposed to mean. However, the real and only issue under 35 U. S. C. 103 is whether the invention as a whole would have been obvious to those skilled in the art at the time the development occurred in view of the state of the art as we are able to glean it from the references cited. *All* of the references may be used to show what the art knew, and in that sense "combined". *In re Adams,* 356 F. 2d 998 (CCPA, 1966).

Apparently the thrust of appellant's arguments is to suggest that the trial court had no basis for combining references in the antenna art because there was no known "log-periodic method of designing frequency independent antennas." Appellant acknowledges that a method existed prior to Isbell for designing log-periodic antenna structures (Page 17). This, of course, was fully disclosed in the DuHammel and Ore publication as the Court below noted in its opinion. Appellant suggests that the issue as to whether patentable invention exists hinges on whether you can predict whether any log-periodic antenna would have frequency independent properties. That is not a proper statement of the issue in this case. The issue may properly be stated as . . .

> whether the Isbell antenna involves a combination of elements known in the prior art and combined in a manner dictated by a known theory of antenna design.

Appellant also contends in the concluding portion of its section on the state of the art prior to Isbell that Isbell was the first to invent a log-periodic antenna having electrical characteristics and structural design attributes that made it especially adaptable as a television antenna. Appellant says that it did not have the bulk of the DuHamel and Rumsey configurations. This, of course, suggests that the DuHamel publications and structures were and are of no significance in any respect. Acceptance of this premise requires that we close our eyes to the existence of the material and say that "for Isbell" we will say that DuHamel's work (and others) should not be considered for no reason (apparently) other than appellant states it does not exist.

Appellant represents to this Court that the Isbell antenna was the first planar log-periodic array that had unidirectional characteristics. The record shows otherwise. Appellant has ignored the Channel Master K. O. antenna in evidence in this case (DX J-6, J-6a).

The concluding statement on page 20 referring to the Isbell antenna is contradicted in the record by the testimony of expert witnesses at the trial. Appellant states that the Isbell antenna constituted the best practical solution to the problem of wide-band radio and TV reception. We direct the attention of the Court to the testimony of Dr. Yang that an antenna in accordance with the Isbell teaching would be ill suited for TV applications (SR 80). This is corroborated by appellant's own witness, Mr. Harris, at least to the extent that he stated that the Isbell antenna structure did not have all of the desirable characteristics for an acceptable commercial application (SR 85).

The same DuHamel and Ore article states that the wire trapezoidal tooth structures were tested at various angles between the planar halves (referred to as angle ψ). The angle ψ was reduced down to as little as seven degrees (Table 4, DX A-1, page 146, R 184). Figure D illustrates the actual magnitude of a 7° angle. For all practical purposes, the planar halves of the particular DuHamel structure under test would be in the same plane.

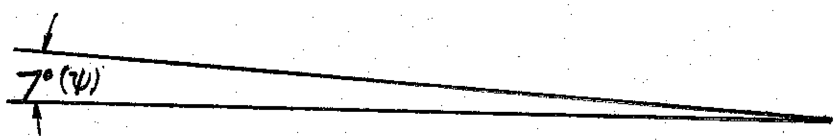


Figure D. (Table 4, DuHamel and Ore Article, DX A-1, page 146.)

This then is the state of the art with respect to the prior DuHamel work developed before the Isbell subject matter. To obtain the Isbell structure, one need only substitute linear dipoles for the triangular-toothed dipoles as depicted in Figure E herein and reduce the angle ψ between planar halves, such as DuHamel suggests in Table 4 (Figure D here). Dr. Yang reviewed in detail the various structures shown in the DuHamel and Ore article (DX A-1) and how one evolved from the other. He illustrated how, in view of these DuHamel structures, the Isbell structure follows as a natural and obvious extension thereof (R 137-139).

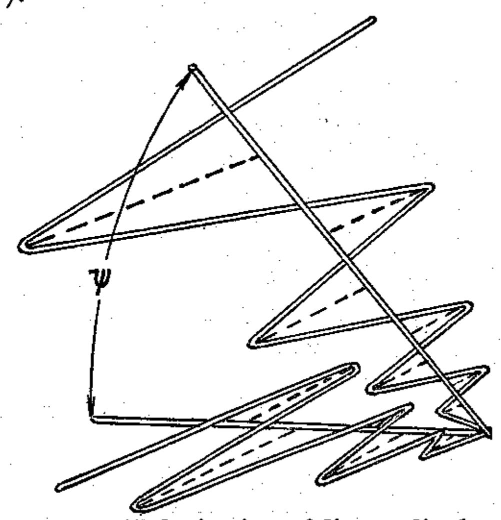


Figure E. (Substitution of linear dipoles for triangular teeth.)

Appellant's representation that there was no "log-periodic method of designing frequency independent antennas" leaves a credibility gap in view of the testimony of appellant's own expert, Mr. Harris. When asked how he arrived at the conclusion that the accused antennas were log-periodic frequency independent antennas, Mr. Harris testified that he arrived at his opinion by the simple expedient of an analysis of the Winegard Company antenna structures based upon the generalized theory of log-periodic antennas (SR 22). If one need only visually observe an antenna structure and apply the generalized principles of log-periodic antenna theory to conclude that it in fact has frequency independent operation, then one can as easily conclude whether any given structure has those characteristics by the same process. Accordingly, if we accept appellant's improper statement of the issue of invention in its brief, then a conflict is evident with respect to the considered opinion of its expert witness, Mr. Harris, who indicated that it is possible to make a prediction of the kind appellant states it is impossible to make. Whom are we to believe?

The additional references in appellant's brief to other mechanical combinations and the Lewis and Clark expedition from St. Louis, Missouri to Portland, Oregon need not be commented upon here.

STATE OF THE ART PRIOR TO ISBELL.

In a discussion of the state of the art prior to Isbell's work appellant refers to the "log-periodic" antennas invented by Dr. DuHamel in 1956 or 1957 having the appearance of a "bow-tie" and includes an illustration thereof in Figure 2 of its brief. Appellant points out the problems faced with antennas of this type. A clear and unmistakable impression is left with the reader that it is the "bow-tie" structures of Figure 2, and those structures only, which the DuHamel and Ore Publication (DX A-1) discloses and that this constitutes the Isbell "prior art". This is not the case.

The particular DuHamel and Ore publication (DX A-1) deals primarily with unidirectional log-periodic antenna structures rather than bi-directional as only a casual observation will disclose. The "bow-tie" structure is referred to in the introduction of that article as a common example of one of the types of frequency independent antennas known at the time of the article. The remaining 11 pages of the 12 page article deal with trapezoidal-tooth and wire-outline structures of particular significance which appellant chooses to ignore in its brief. It is to these structures, however, that we must direct our attention.

Figure A shows one such structure of the DuHamel and Ore article (Figure 2, DX A-1, page 140, R 178) which is designated as the "trapezoidal-tooth structure."

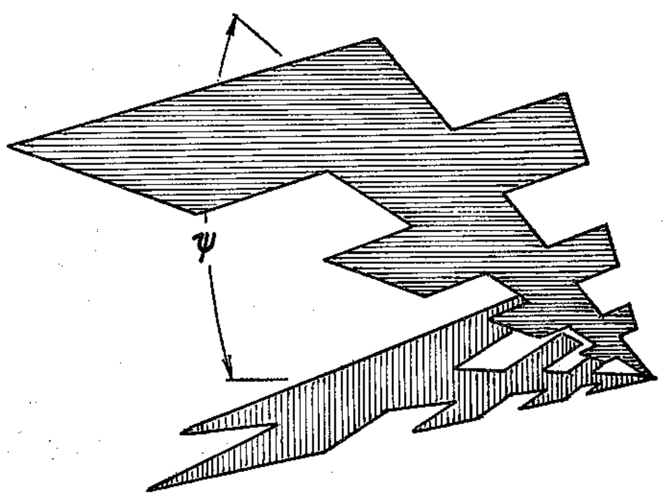


Figure A. (Fig. 2, DuHamel and Ore Article, DX A-1.)

This suggested the "wire, trapezoidal-tooth structure" to DuHamel as shown in Figure B, taken from the DuHamel article (Figure 9(a), DX A-1, page 144, R 182). A further variation was developed by DuHamel referred to as the "triangular-tooth" structure. This structure is depicted in Figure C, also taken from the DuHamel and Ore article (Figure 15, DX A-1, page 147, R 185).

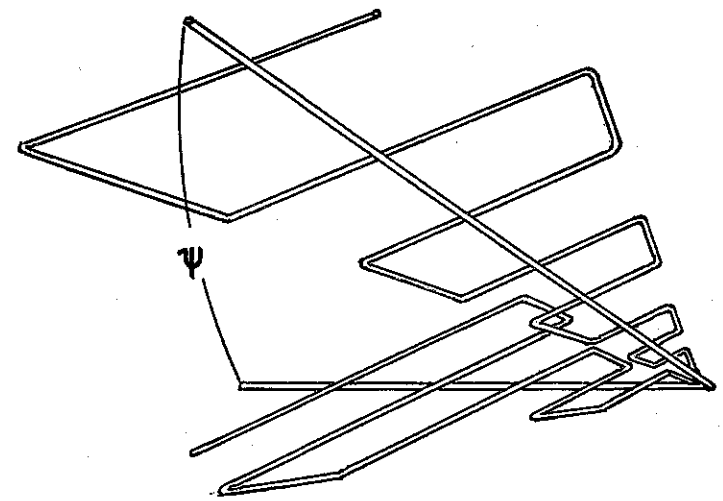


Figure B. (Fig. 9a, DuHamel and Ore Article, DX A-1.)

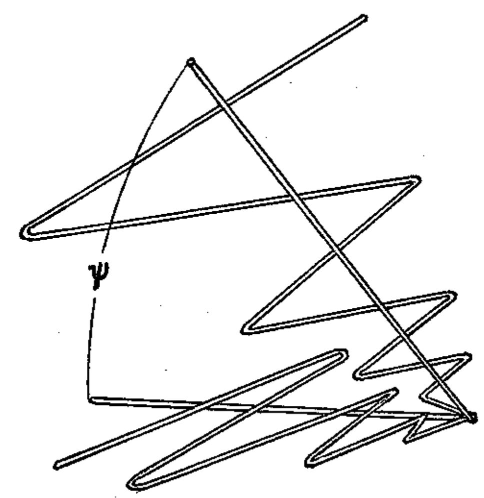
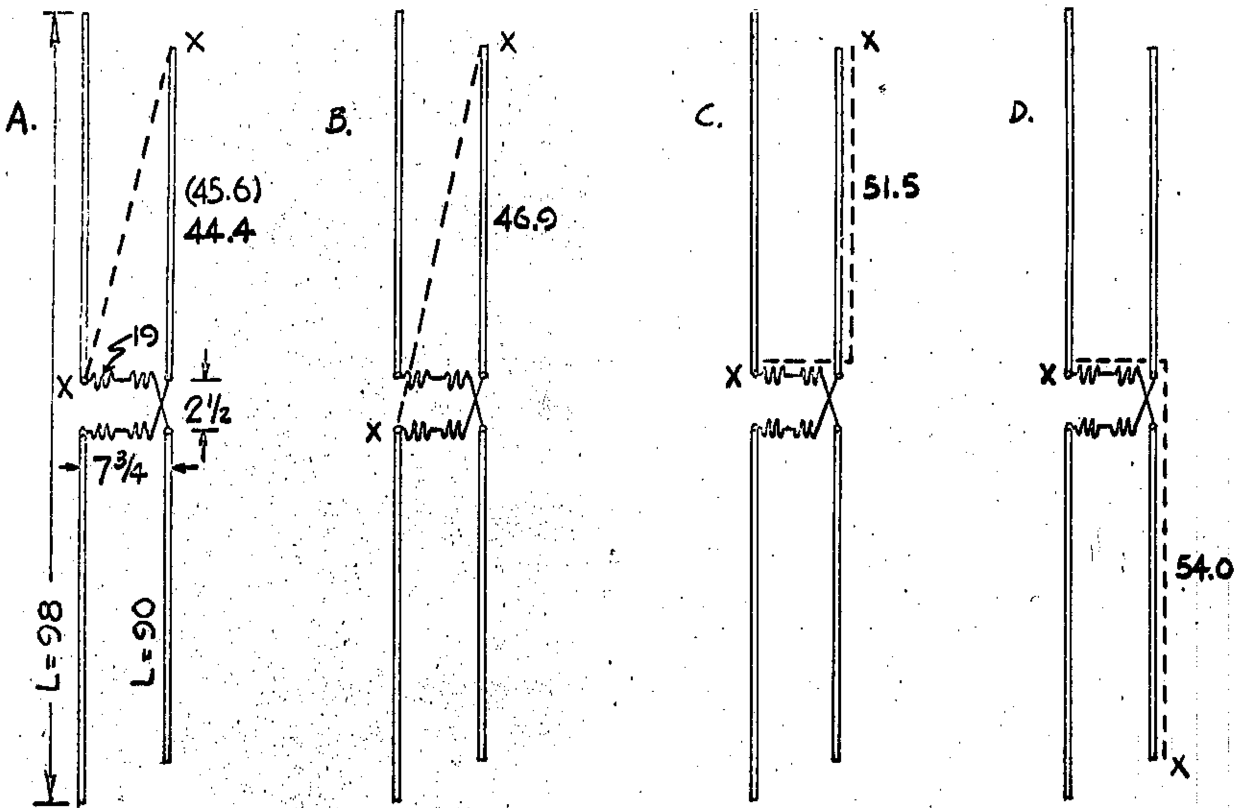
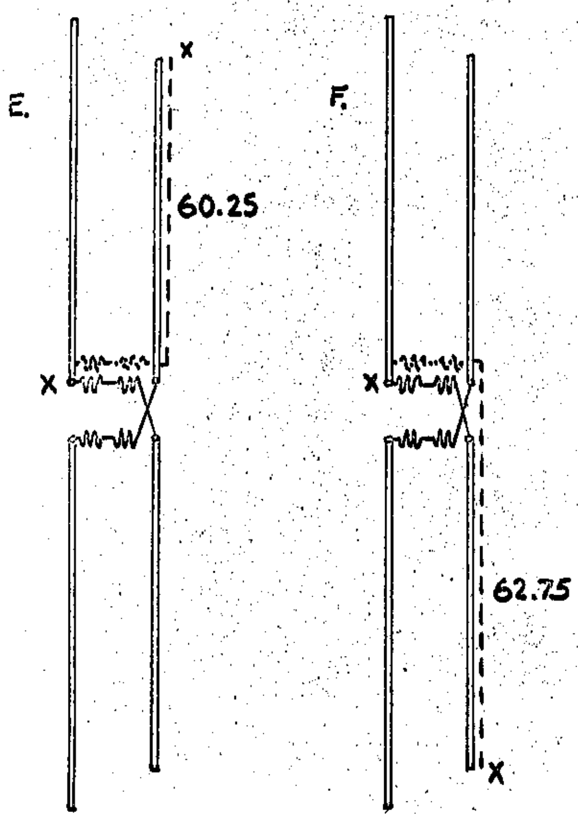


Figure C. (Fig. 15, DuHamel and Ore Article, DX A-1.)





CLAIMS 14 & 15:

"* * * each dipole and the feeder between it and the adjacent dipole constituting a cell,

the dimension of the several cells measured from the point of connection of one dipole and the feeder to the outer end of the next smaller adjacent dipole also decreasing from one cell to the next in the direction of decreasing dipole length according to a substantially constant scale factor * * *" (emphasis added)

APPENDIX 'A'

IN THE UNITED STATES DISTRICT COURT

FOR THE SOUTHERN DISTRICT OF IOWA

DAVENPORT DIVISION

FILED

JUN 23 1967

F. E. VAN ALSTINE
CLERK, U. S. DISTRICT COURT
SOUTHERN DISTRICT OF IOWA

UNIVERSITY OF ILLINOIS FOUNDATION, Plaintiff,

vs.

WINEGARD COMPANY, Defendant.

Civil No. 3-695-D

MEMORANDUM OPINION

This action was brought by the plaintiff University of Illinois Foundation, the owner by assignment of U. S. Patent 3,210,767, issued to Dwight E. Isbell on October 5, 1965 (hereinafter referred to as the Isbell Patent and attached hereto as Appendix A), against the defendant Winegard Company wherein the plaintiff seeks a finding that said patent has been and is being infringed by the defendant. In its answer the defendant alleges, inter alia, invalidity of the patent on the grounds that the invention was disclosed more than one year prior to the date of the application for the patent and that, at the time made, the invention was obvious to one skilled in the art. Jurisdiction is established by virtue of 35 U.S.C. § 381 and 28 U.S.C. § 1338.

Inasmuch as the defendant alleges invalidity of the patent as a defense, the Court must determine initially whether or not the Isbell patent is valid. General Mills, Inc. v. Pillsbury Co., _______ F.2d ______ (8th Cir., June 8, 1967); American Infra-Red Radiant Co. v. Lambert Indus., Inc., 360 F.2d 977, 983-84 (8th Cir., 1966). Of course, a patent, from the fact of its issuance is presumed to be valid. 35 U.S.C. § 282;

Radio Corporation of America v. Radio Engineering Laboratories, Inc., 293 U.S. 1, 7-8 (1934); L & A Products, Inc. v. Britt Tech. Corp., 365 F.2d 83, 86 (8th Cir., 1966); American Infra-Red Radiant Co. v. Lambert Indus.,Inc., supra at 988-89. However, this presumption of validity is weakened when, as in this case, there are prior art references or alleged disclosures of the patent before the Court that were not considered by the patent office during the prosecution of the application for the patent. Imperial Stone Cutters, Inc. v. Schwartz, 370 F.2d 425, 429 (8th Cir., 1966); American Infra-Red Radiant Co. v. Lambert Indus.,Inc., supra at 989; Greening Nursery Co. v. J & R Tool & Mfg. Co., 252 F. Supp. 117, 139 (S.D. Iowa 1966), aff'd _______F.2d ______ (8th Cir., May 9, 1967).

There are three separate conditions precedent to patent validity. They are: Novelty, utility, and nonobviousness. 35 U.S.C. §§ 101-03; Graham v. John Deere Co., 383 U.S. 1, 12 (1966); United States v. Adams, 383 U.S. 39, 48 (1966); L & A Products, Inc. v. Britt Tech. Corp., supra at 85. In this case the defendant relies on lack of novelty (Title 35 U.S.C. Section 102) and obviousness (Section 103) as barring patentability. It is the opinion of the Court that the issue of obviousness is dispositive of this case. Therefore, that issue will be first considered.

While the ultimate question of patent validity is one of law, the determination of the question of obviousness lends itself to several basic factual inquiries. Graham v. John Deere Co., supra at 17; L & A Products, Inc. v. Britt Tech. Corp., supra at 86. In addition to setting out the scope of the patent in suit, the scope and content of the prior art must be defined so that a determination can be made as to whether the differences between the patent in suit and the pertinent prior art would have been obvious to one ordinarily skilled in the art. If such differences as may exist would have been obvious to a person ordinarily skilled in the art, the obviousness test of 35 U.S.C. § 103 has not been met and the patent will be invalid. Graham v. John Deere Co., supra, at 37; General Mills, Inc. v. Pillsbury Co., supra.

The Patent in Suit

The Isbell Patent is entitled "Frequency Independent Unidirectional Antennas" and relates to antennas designed for the transmission and reception of electromagnetic radio frequency signals. These signals are used for the broadcasting of many types of communications including radio and television signals. The Isbell antenna consists of a plurality of elements called "dipoles"[1] which are arranged in relation to each other and

1. Generally, in this context, a simple straight dipole antenna element consists of two elongated metallic conductors (wires, rods or tubes) arranged approximately colinearly in such a manner that there is a small gap or terminal between their inner ends, at which point a transmission line is attached. The familiar "rabbit-ear" indoor television antenna is a simple dipole having its arms at an angle rather than in a straight line. When immersed in an electromagnetic field the dipole element will intercept electromagnetic radio waves and produce a voltage across the terminal. This voltage is carried to the receiver by means of the transmission line. The dipole antenna element, like any other electrical conductor, will intercept radio energy from the atmosphere to a limited extent, regardless of the frequency of the energy being transmitted. There is, however, a special condition, known as "resonance", in which the dipole is strongly receptive, which occurs when the dipole is of a particular length in relationship to the wavelength of the radiated energy. This condition occurs primarily when the overall length of the dipole is one-half of the wavelength of the radio wave. Thus, it is apparent that a dipole can be "tuned" for optimum reception of a particular radiowave frequency by adjusting the overall length of the dipole. The relative ability of one antenna to produce a signal (i.e., a radio frequency voltage) at a given location distant from the transmitting station in comparison with another antenna similarly located is a measure of the antenna's "gain," a technical term used in the industry in reference to an antenna's signal-producing capabilities.

connected to each other in a particular manner. Generally, as stated in the patent specification, "the antennas of the invention are coplanar dipole arrays consisting of a number of dipoles arranged in side-by-side relationship in a plane, the length and the spacing between successive dipoles varying according to a definite mathematical formula, each of the dipoles being fed by a common feeder (transmission line) * * * ."[2] According to the patent specification,

> The lengths of the dipoles and the spacing between dipoles are related by a constant scale factor τ defined by the following equations:
>
> $$\tau = \frac{L(n+1)}{Ln} = \frac{\Delta S(n+1)}{\Delta Sn}$$
>
> where τ is a constant having a value less than 1, Ln is the length of any intermediate dipole in the array, L(n+1) is the length of the adjacent smaller dipole, ΔSn is the spacing between the dipole having the length Ln and the adjacent larger dipole, and ΔS(n+1) is the spacing between the dipole having the length Ln and the adjacent smaller dipole.[3]

The feeder or transmission line consists of two conductors, one of which is connected to the inner end of one-half of each dipole, the other being connected to the inner end of the other half of the dipole, and transposed between connections of successive dipoles in such a manner that each conductor is connected alternately to the left and right halves of successive dipoles. (See Appendix A, Fig. 1.)

Antennas designed in accordance with the patent specifications are claimed to have unidirectional radiation patterns and high quality performace which are, over a wide band of frequencies, essentially independent of the frequency of the electromagnetic radio waves being transmitted or received. An

2. Isbell Patent, Col. 1, lines 14-19. See App. A.

3. Isbell Patent, Col. 1, lines 50-62. See App. A.

antenna with such characteristics is, of course, desirable when the reception of many different frequencies is required as one such antenna may be used in place of many antennas which are each capable of receiving a limited number of frequencies. Since VHF television signals are broadcast over a range of frequencies of 54 megacyles/second to 216 megacycles/second,[4] an antenna capable of receiving high quality signals with uniform performance characteristics in that range of frequencies would be of commercial utility. This is particularly true in respect to the reception of color television signals where the minimum standards of performance are higher than those required for satisfactory black and white television reception.

There are fifteen claims in the Isbell patent. See Appendix A. All of the claims except numbers 6, 7 and 8 are claimed to be infringed by one or more of twenty-two models of defendant's antennas which are designed for the reception of television signals.[5] Specifically, all twenty-two models

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4. Channels 2-6 broadcast over radiowave frequencies 54-88 megacycles/second, each channel being assigned a band 6 megacycles wide in which to broadcast. Thus, channel 2 broadcasts over the range 54-59 megacycles/second; channel 3, 60-65 megacycles/second; etc. Channels 7-13 broadcast over frequencies 176-216 megacylces/second, with 89-175 megacycles/second being assigned to non-television broadcasting. While some of the antennas accused of infringing are designed for the reception of VHF and UHF (470-890 megacycles/second) signals, it is only the VHF sections of these antennas that are alleged to be infringements of the Isbell patent.
5. The Winegard antennas that are alleged to be infringements of the Isbell patent are the models with the following numbers:

Chromaflex	B-445	R.C.A.	10-B-200
"	B-550	"	10-B-300
"	B-555	"	10-B-400
"	B-660	"	10-B-1010
"	B-770	"	10-B-1020
"	B-105	"	10-B-1030
"	B-335	"	10-B-1040
Chromatel	CT-40	"	10-B-1050
"	CT-80	"	10-B-1120
"	CT-90	"	10-B-1130
"	Ct-100	"	10-B-1140

are alleged to be literal infringements of claims 14 and 15 and also within the inventive concept of claims 1-5 and 9-13. In addition, one of the antennas, the chromatel CT-100, is alleged to be a literal infringement of claims 1, 2, 9, 10, 11, and 12. It should be noted here that while the portions of the antennas which are charged as infringing are designed solely for the reception of VFH television signals, the Isbell antenna is not so limited. It is designed both as a receiving antenna and a transmitting antenna for use in an unlimited range of frequencies. For example, the specification indicates that the antenna has very high performance characteristics over as high a range as 1100 to 1800 mc/sec.[6]

Prior Art

Four prior patents are cited in the patent as having been considered by the patent examiners. One of these patents, five other U. S. patents not referred to by the examiners, an article published on March 31, 1958 and three antennas in use prior to 1959 are among the references relied upon by the defendant as revealing the prior art at the time of the invention. An examination of some of these references will be helpful in defining the state of the prior art on May 3, 1960, the date of the filing of the application for the patent.

The Katzin patent (U.S. Patent No. 2,192,532, the first page of which is attached hereto as Appendix B) cited by the patent office reveals an antenna consisting of an array of dipole elements of different lengths arranged in a side-by-side relationship in a plane. While some of the illustrated embodiments of the Katzin invention show antennas having several elements of one length arranged parallel to several elements of

6. Isbell Patent, Col. 2, lines 47-52. See App. A.

another length, one illustrated embodiment (Figure 3c, Appendix B) shows an array described in claim seven of the patent as being "a plurality of aerial elements, all of differing length, continuously tapering in length from one end of said antenna to the other * * * ."[7] The patent also suggests, in claim 11 thereof, that the spacing between the shorter elements may be less than that between the longer elements.[8] The teaching of the Katzin patent is that if elements, or groups of elements, of differing lengths are combined into one array, each of the elements, or groups of elements, "will respond most efficiently to its corresponding band of frequencies, so that the combination of two or more such groups * * * will give the result of a high response for a wider frequency band."[9]

One of the antennas cited as prior art by the defendant is the Channel Master "K. O." antenna model 1023, produced and marketed by the Channel Master Corporation of Ellenville, N. Y. between September 1954 and December 1958. A schematic diagram of this antenna, Exhibit DX-G-16, is attached hereto as Appendix C. This antenna is an array of <u>folded</u> dipoles,[10] each

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7. U.S. Patent No. 2,192,532, p. 2, Col. 2, lines 54-58.
8. U.S. Patent No. 2,192,532, p. 3, Col. 2, lines 5-14; See also Fig. 3d, App. B.
9. U.S. Patent No. 2,192,532, p. 2, Col. 1, lines 16-21.
10. Folded dipoles are simple dipoles, see n. 1, <u>supra</u>, which have been altered by adding another conductor in such a manner that it is approximately parallel to the simple dipole and attached to the outer ends of each half of the simple dipole. The resulting structure is an elongated loop having a terminal point midway along one of its longer sides. (See App. C) Folded dipoles have somewhat different characteristics than straight or simple dipoles, the primary differences being that folded dipoles have better performance over a greater bandwidth of frequencies and that folded dipoles have a greater resistance to the flow of electric current than do simple dipoles. This resistance to the flow of current is known as "impedence." In order to achieve the maximum transmission of the signal to the receiver, the impedence of the antenna, the transmission line and the receiver should be as nearly equal

of a different length, arranged in a coplanar side-by-side relationship decreasing in length from one end of the array to the other. The spacing between the dipole elements is irregular, the elements not being equally spaced and the spacing not varying progressively from one end of the array to the other. The feeder or transmission line running between the elements consists of two conductors, one of which is connected to one end of the folded dipole at the terminal point, the other connected to the other end of the dipole at the terminal point, and transposed between dipoles such that each conductor is alternately connected to the left and right ends of successive dipoles. Transposed feeder lines are also shown in the Koomans Patent (U.S. Patent No. 1,964,189, the first page of which is attached hereto as Appendix D) and the Winegard Patent (U.S. Patent No. 2,700,105, the first page of which is attached hereto as Appendix E), both of which are cited as prior art by the defendant. The White Patent (U.S. Patent No. 2,105,569, the first page of which is attached hereto as Appendix F) also uses transposed feeder lines in conjunction with dipole elements decreasing in length from one end of the array to the other. However, the White array is "center-fed," that is, connected to the down lead transmission line which leads to the receiver, at the center of the array, rather than at the end of the array. The antennas described in the Katzin, Koomans, and Winegard patents noted above and the "K. O." antenna, as well as the Isbell antenna, are all fed at the end of the antenna having the smaller

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10. (Con'd) as possible. Television transmission line and receivers have an impedence set by FCC regulation at about 300 ohms. A simple dipole has an impedence of about 75 ohms while a folded dipole has an impedence of about 300 ohms.

elements.

The article cited by the defendant Winegard as prior art is "Logarithmically Periodic Antenna Designs" published by R. H. DuHamel and F. R. Ore on March 31, 1958. This article explains the elements of the theory of logarithmically periodic (log periodic) antennas and the development of several such antennas. Generally stated, log periodic antennas are designed according to the theory that an antenna "design cell"[11] having high performance characteristics for reception of a limited band or period of radio frequency signals, if altered in all dimensions by a constant scale factor will have high performance characteristics for reception of a band of signals having wavelengths which vary from the wavelengths of the first band of frequencies by the same constant scale factor. Thus, according to the theory, if an antenna design cell has certain characteristics for reception of particular frequency wavelengths, an antenna geometrically similar but reduced in all dimensions by a scale factor of .5 will have similar characteristics for reception of frequencies of wavelengths half those of the first. The theory continues that if a particular design cell is reduced successively by a constant scale factor which is less than 1, and repeated periodically in one antenna "array", the array will have the characteristics of the design cell over a broader band of frequencies which is limited only by the largest and smallest of the geometrically similar design cells which are

11. The term "design cell" is used herein to refer to a structural unit of an antenna which is capable of receiving and transmitting electromagnetic radio energy. A simple or folded dipole and an adjacent section of transmission line are examples of such antenna design cells. A particular antenna array may be composed of one or more similar or dissimilar design cells.

repeated in the array. Because the performance of the antennas so designed is theoretically the same over any band of frequencies for which the antenna is designed the antennas are termed Frequency Independent Antennas. The application of this theory to antenna design appears to be limited only by the conditions that the design cell used must have uniform performance over a single period and that the overall array, the periodic repetition of the cell, not cause an "end effect"[12] that would destroy the frequency independence of the array.

The formula set out by DuHamel and Ore as defining the relationship between the repeated, or periodic, design cells is: $\tau = \frac{R_{n+1}}{R_n}$, which defines a constant proportional relationship between like elements of the design. In this case the formula relates to the radii of circular structures. Of course, in the case of geometrically similar designs all dimensions of one design are proportionally equal to all dimensions of the other similar designs. That is, they must all vary proportionally. The theory of the log periodic antenna was adopted by Isbell in his work and the formula, $\tau = \frac{L(n+1)}{L_n} = \frac{\Delta S(n+1)}{\Delta S_n}$ where τ is a constant having a value of less than 1, can be

12. Very generally stated, "end effect" is a term used to describe a bouncing back and forth, from one end of an antenna array to the other, of any energy that is not fully transmitted or absorbed by the elements of the antenna as the energy travels initially along the antenna. This bouncing, or reflection, back and forth may cause shadows or ghosts in the reception of a television picture. Thus, in order to avoid this end effect an antenna should be designed to have sufficient elements to radiate or absorb all of the energy as it passes from one end of the antenna to the other so that there will be no such reflection of the energy back down the antenna.

seen to be a simple adaptation of the DuHamel-Ore formula[13] and its mathematical equivalent.

The Invalidity of the Patent

Keeping in mind the prior art previously discussed, it can be seen that an antenna with the general parameters of the Isbell Patent will result from a combination of the dipole array of Katzin with the transposed feeder line of the Channel Master "K. O. " or the Koomans or Winegard Patents. Such an antenna would consist of a coplanar side-by-side array of straight dipole elements of differing lengths which decrease in length and spacing from one end of the array to the other (as disclosed by claims 7 and 11 of the Katzin patent), fed at the small end of the array by a two conductor transmission line that is transposed between successive elements (as disclosed by the Koomans and Winegard Patents and the Channel Master "K. O." antenna). Further, if

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13. While DuHamel and Ore defined circular structures by relating the radii of different parts of one cell to the radii of another, Isbell has defined linear structures by relating the lengths and spacings of one design cell to another. That these are alternative means of expressing the same mathematical relationsip is evident from an examination of Figure 1 of the Isbell patent and the discussion, found in Col. 1, line 63 to Col. 2, line 2 of the patent, relative to the distance from the base line O, in Figure 1, to the dipole having the length Ln. If the distance from the base line O to dipole having the length Ln were the radius of a circle having its axis at line O and its circumference tangent to the same dipole, the distance represented by Xn ("the distance from the base line O to the dipole having the length Ln", see Col. 1, lines 71-72 of Appendix A) would be equal to Rn, where Rn is the radius of the said circle having its axis at O and its circumference tangent to the dipole of length Ln; then, it is easily seen that the formulas $\tau = \frac{R_{n+1}}{R_n}$ (Isbell) and $\tau = \frac{X_{(n+1)}}{X_n}$ (DuHamel & Ore) are different but equal mathematical expressions of the same proportional relationship.

the length and spacing of the dipole elements in such an antenna are adjusted by the log periodic theory of antenna design which dictates that the periodic or repeating cells (here a dipole element and adjoining section of transmission line) shall be geometrically similar and related to each other in size by a constant scale factor, the result is the Isbell antenna disclosure. It is thus apparent that the Isbell antenna is a combination of elements, all known in the prior art and also that these known elements were combined in the Isbell antenna in a manner dictated by a theory also known in the prior art. Therefore, the critical question is whether such a combination would have been obvious to one reasonably skilled in the art of antenna design. United States v. Adams, supra at 50-52; Kell-Dot Indus., Inc. v. Graves, 361 F.2d 25, 30 (8th Cir., 1966); Infra-Red Radiant Co. v. Lambert Indus., Inc., supra at 988. Those skilled in the art at the time of the Isbell application knew (1) the log periodic method of designing frequency independent antennas, (2) that antenna arrays consisting of straight dipoles with progressively varied lengths and spacings exhibit greater broad band characteristics than those consisting of dipoles of equal length and spacing and, (3) that a dipole array type antenna having elements spaced less than 1/2 wavelength apart could be made unidirectional in radiation pattern by transposing the feeder line between elements and feeding the array at the end of the smallest element.

It is the opinion of the Court that it would have been obvious to one ordinarily skilled in the art and wishing to design a frequency independent unidirectional antenna to combine these three old elements, all suggested by the prior art references previously discussed.[14] The test of obviousness is the proper test to be applied in determining whether a new combination of known elements is patentable. American Infra-Red Radiant Co. v. Lambert Indus., Inc., supra at 988. When one skilled in the art with the prior art references before him could have, without the exercise of inventive faculty, combined old elements known in the art to produce the plaintiff's "invention," the "invention" does not rise to the level of patentability notwithstanding the fact that it may be an improvement over the

14. It should also be noted that the File Wrapper of the Isbell patent indicates that on November 9, 1960, all original 9 claims (final claims 1-8 and another never approved) were initially rejected by examiner G. N. Westby as being met by Katzin (Patent No. 2,192,532, App. C) in view of other patents teaching the crossing of the feeder line and the use of straight tubular conductors. On May 10, 1961, Isbell submitted an amendment to the Patent Office wherein he argued that "there is certainly no teaching or suggestion in the Katzin patent of an arrangement in which both the length of successive dipoles and the spacing between said dipoles vary in a manner such that the ratio of the length of adjacent dipoles is a constant which is also equal to the ratio of the spacings between adjacent dipoles. Unless both of these conditions are met the antenna does not have the remarkably wide band paths, the high gain and the directivity exhibited by the antennas of the invention." (Emphasis in the original). Subsequently, original claims 1-8 were allowed by examiners H. K. Saalbach and Eli Lieberman as were 7 additional claims added as a result of an interference proceeding and further amendments by the applicant. It appears, thus, that the above argument in regard to the constant proportional relationship of the lengths and spacings of the elements and the importance of such relationship convinced the Patent Office that the Isbell disclosure was patentable. However, there is nothing in the file wrapper to indicate that the patent examiners were aware of published work of DuHamel and Ore, their formula, or the log periodic theory of antenna design all of which was a part of the prior art at the time of the application.

prior art. Kell-Dot Indus., Inc. v. Graves, supra at 29. The Court, upon full consideration of the record herein, finds that the disclosure of Isbell's Patent No. 3,210,767 is lacking in the prerequisite non-obviousness and is, therefore, invalid.

Inasmuch as an invalid patent cannot be infringed, Imperial Stone Cutters, Inc. v. Schwartz, supra at 429; Kell-Dot Indus., Inc. v. Graves, supra at 28, the question of infringement is rendered moot and is, therefore, not decided by this Court.

The foregoing shall constitute the findings of fact and conclusions of law pursuant to Fed. R. Civ. P. 52(a).

IT IS ORDERED that judgment will be entered for the defendant with costs, exclusive of attorney's fees, taxed to the plaintiff.

Dated this 23rd day of June, 1967.

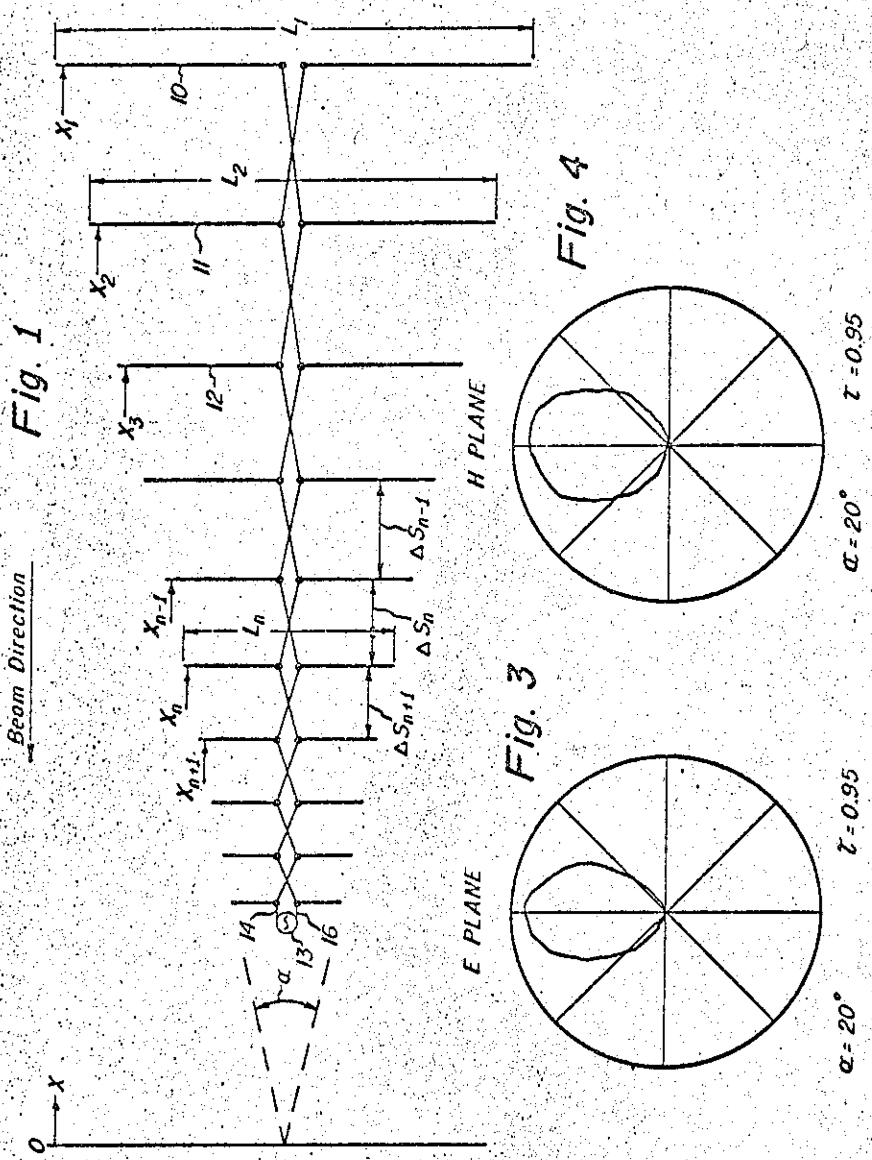
CHIEF JUDGE

APPENDIX A

Oct. 5, 1965 D. E. ISBELL 3,210,767

FREQUENCY INDEPENDENT UNIDIRECTIONAL ANTENNAS

Filed May 3, 1960 2 Sheets-Sheet 1



INVENTOR.
Dwight E. Isbell
BY
Merriam, Smith & Marshall
ATTORNEYS

Oct. 5, 1965 D. E. ISBELL 3,210,767

FREQUENCY INDEPENDENT UNIDIRECTIONAL ANTENNAS

Filed May 3, 1960 2 Sheets-Sheet 2

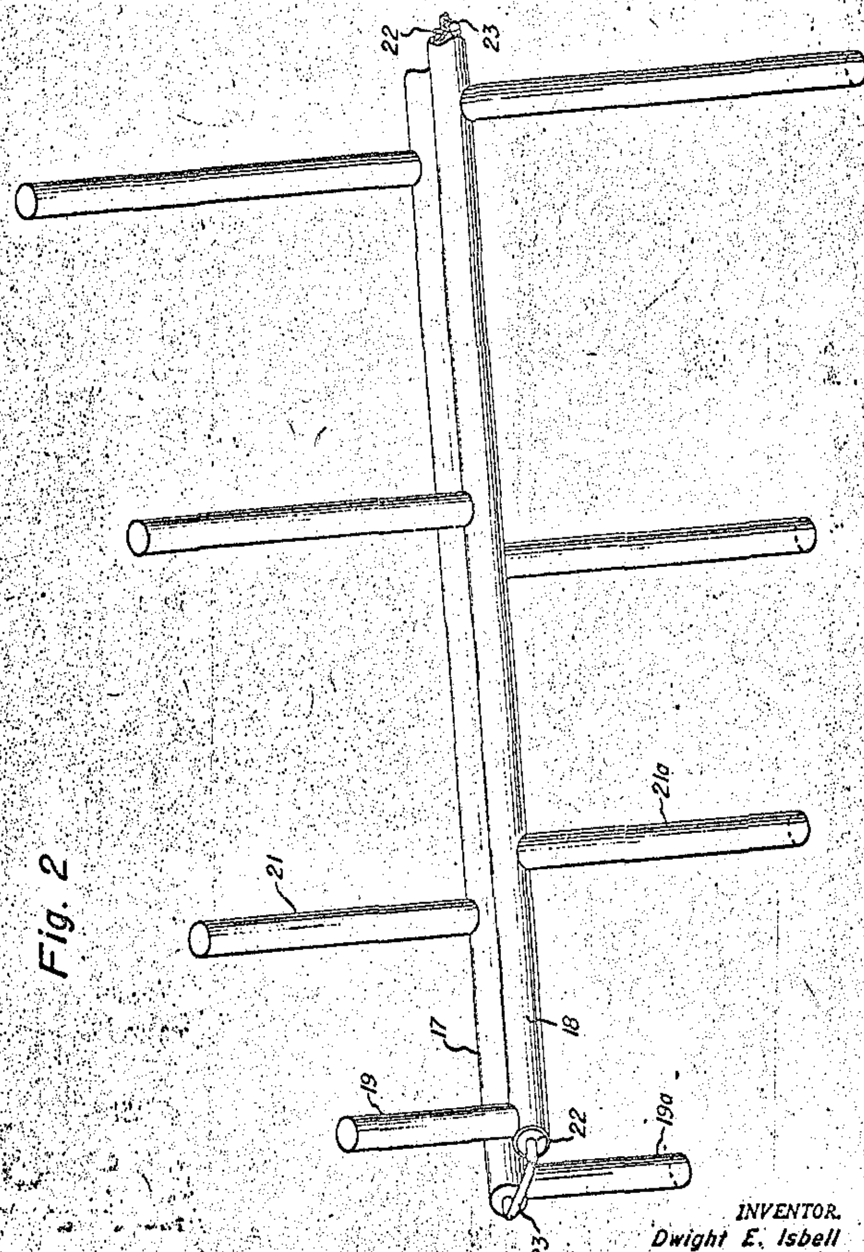


Fig. 2

INVENTOR.
Dwight E. Isbell

BY

Merriam, Smith & Marshall
ATTORNEYS

3,210,767

FREQUENCY INDEPENDENT UNIDIRECTIONAL ANTENNAS

Dwight E. Isbell, Seattle, Wash., assignor to The University of Illinois Foundation, a non-profit corporation of Illinois

Filed May 3, 1960, Ser. No. 26,589
15 Claims. (Cl. 343—792.5)

This invention relates to antennas, and more particularly, it relates to antennas having unidirectional radiation patterns that are essentially independent of frequency over wide bandwidths.

The antennas of the invention are coplanar dipole arrays consisting of a number of dipoles arranged in side-by-side relationship in a plane, the length and the spacing between successive dipoles varying according to a definite mathematical formula, each of the dipoles being fed by a common feeder which introduces a phase reversal of 180° between connections to successive dipoles. The antennas of the invention provide unidirectional radiation patterns of constant beamwidth and nearly constant input impedances over any desired bandwidth.

The invention will be better understood from the following detailed description thereof taken in conjunction with the accompanying drawing, in which:

FIGURE 1 is a schematic plan view of an antenna made in accordance with the principles of the invention;

FIGURE 2 is an isometric view of a practical antenna embodying the invention; and

FIGURES 3 and 4 are radiation patterns of a typical antenna, in the E plane and H plane, respectively.

Referring to FIGURE 1, it will be seen that the antenna of the invention was composed of a plurality of dipoles 10, 11, 12, etc., which are coplanar and in parallel, side-by-side relationship. It will be noted that the lengths of the successive dipoles and the spacing between these dipoles is such that the ends of the dipoles fall on a pair of straight lines which intersect and form an angle α. In the preferred embodiment the antenna is symmetrical about a line passing through the midpoints of the dipoles, as shown.

The antenna is fed at its narrow end from a conventional source of energy, depicted in FIGURE 1 by alternator 13, by means of a balanced feeder line consisting of conductors 14 and 16. It will be seen that the feeder lines 14 and 16 are alternated between connections to consecutive dipoles, thereby producing a phase reversal between such connections.

The lengths of the dipoles and the spacing between dipoles are related by a constant scale factor τ defined by the following equations:

$$\tau=\frac{L_{(n+1)}}{L_n}=\frac{\Delta S_{(n+1)}}{\Delta S_n}$$

where τ is a constant having a value less than 1, L_n is the length of any intermediate dipole in the array, $L_{(n+1)}$ is the length of the adjacent smaller dipole, ΔS_n is the spacing between the dipole having the length L_n and the adjacent larger dipole, and $\Delta S_{(n+1)}$ is the spacing between the dipole having the length L_n and the adjacent smaller dipole.

It will be seen from the geometry of the antennas, as given above, that the distance from the base line 0 at the vertex of the angle α to the dipoles forming the array are defined by the equation:

$$\tau=\frac{X_{(n+1)}}{X_n}$$

where X_n is the distance from the base line 0 to the dipole having the length L_n, $X_{(n+1)}$ is the corresponding distance from the base line to the adjacent smaller dipole, and τ has the significance previously given.

The radiation pattern of the antennas of the invention, having the geometrical relationship among the several parts as defined above, is unidirectional in the negative X direction, i.e., extending to the left from the narrow end of the antenna of FIGURE 1.

The construction of an actual antenna made in accordance with the invention is shown in FIGURE 2. In this antenna the balanced line consists of two closely-spaced and parallel electrically conducting small diameter tubes 17 and 18 to which are attached the dipoles, each of which consists of two individual dipole elements, e.g., 19 and 19a, 21 and 21a, etc. It will be noted that each of the two elements making up one dipole is connected to a different one of said conductors 17 and 18, in a direction perpendicular to the plane determined by said conductors 17 and 18. Moreover, considering either one of the conductors 17 and 18, consecutive dipole elements along the length thereof extend in opposite directions. It will be seen that this construction has the effect of alternating the phase of the connection between successive dipoles, as depicted schematically in FIGURE 1. Although the dipoles of FIGURE 2 are not precisely coplanar, differing therefrom by the distance between the parallel conductors, in practice this distance is very small so that the dipole elements are substantially coplanar and the advantages of the invention are maintained. The antenna of FIGURE 2 may be conveniently fed by means of a coaxial cable 22 positioned within conductor 18, the central conductor 23 thereof extending to and making electrical connection with conductor 17 as shown.

As an example of the invention, an antenna of the type shown in FIGURE 2 was constructed using 0.125 inch diameter tubing for the balanced line and 0.050 inch diameter wire for the elements. The elements were attached to the feeder line with soft solder, and the array was fed with miniature coaxial cable inserted through one of the balanced line conductors. The antenna was defined by the parameters $\tau=0.95$ and $\alpha=20°$. The antenna had a total of 15 dipoles, with the longest dipole element being 2½" long, while the shortest element was one-half of this length, or 1¼". The array was 7½" long.

Typical radiation patterns for the above-described antenna in the E plane and the H plane are shown in FIGURES 3 and 4, respectively. These patterns were found to remain essentially constant over the band of about 1100 to 1800 mc./sec. The minimum front-to-back ratio over this band was 17 db and the directivity over the range from about 1130 to 1750 mc./sec. was better than 9 db over isotropic.

The performance of the above-described antenna clearly indicates that the antennas of the invention provide excellent rotatable beams for use particularly in the HF to UHF spectrum. In comparison to the well-known parasitic types of antennas which bear some resemblance to those of the invention, such as the Yagi array, the antennas of the invention provide a much wider bandwidth with essentially comparable directivity. Advantageously, however, the antennas of the invention need no adjusting for their performance over a wide bandwidth, compared to the parasitic types which must be adjusted by cut-and-try procedures for each frequency. Further experimental work with other antennas similar to that described above has indicated that the preferred values for the parameters which define the antennas of the invention include a range of values for angle α between about 20° and 100°, with τ having a value between about 0.8 and about 0.95. When these parameters have values within the preferred ranges the antennas were found to have essentially frequency independent performance over any desired bandwidth. The upper and lower limits of the bandwidths may be adjusted as desired by fixing the lengths of the longest dipole and the shortest dipole, respectively. It has been determined experimentally that the longest dipole element should be approximately 0.47 wavelength long at the lower limit and the shortest element should be about 0.38 wavelength long at the upper limit. Moreover, in order to provide a suitable front-to-back ratio at the low frequency limit, there should be at least 3 dipoles in the array and preferably about 10 to 30 dipoles.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

What is claimed is:

1. A broadband unidirectional antenna comprising an array of substantially coplanar and parallel dipoles of progressively increasing length and spacing in side-by-side relationship, the ratio of the lengths of any two adjacent dipoles being given by the formula

$$\frac{L_{(n+1)}}{L_n}=\tau$$

where L_n is the length of any intermediate dipole in the array, $L_{(n+1)}$ is the length of the adjacent smaller dipole and τ is a constant having a value less than 1, the spacing between said dipoles being given by the formula

$$\frac{\Delta S_{(n+1)}}{\Delta S_n}=\tau$$

where ΔS_n is the spacing between the dipole having the length L_n and the adjacent larger dipole, $\Delta S_{(n+1)}$ is the spacing between the dipole having the length L_n and the adjacent smaller dipole, and τ has the significance previously assigned, said dipoles being fed in series by a common feeder which alternates in phase between successive dipoles.

2. The array of claim 1 which is symmetrical about a line passing through the midpoint of each dipole in the array.

3. A broadband unidirectional antenna comprising an array of a plurality of substantially coplanar and parallel dipoles of progressively increasing length in side-by-side relationship, the ends of said dipoles falling on a V-shaped line forming an angle α at its vertex, the ratio of the lengths of any pair of adjacent dipoles being given by the formula

$$\frac{L_{(n+1)}}{L_n}=\tau$$

where L_n is the length of the longer dipole of the pair, $L_{(n+1)}$ is the length of the shorter dipole, and τ is a constant having a value less than 1, the dipoles in said array being fed in series by a common feeder which alternates 180° in phase between successive dipoles.

4. The antenna of claim 3 in which the angle α has a value between about 20° and 100° and the constant τ has a value between about 0.8 and 0.95.

5. The antenna of claim 3 in which said feeder is a balanced line which twists 180° between the connections to successive dipoles.

6. A broadband unidirectional antenna comprising a balanced feeder line consisting of two closely spaced, straight and parallel conductors, a plurality of dipoles each consisting of two dipole elements, one of which elements is connected to one of said conductors, the other element being connected directly opposite the first to the other of said conductors, the elements of any dipole extending in opposite directions perpendicular to the plane determined by said conductors, consecutive dipole elements on each of said conductors extending in opposite directions, the ratio of the lengths of the elements in any two adjacent dipoles being given by the formula

$$\frac{l_{(n+1)}}{l_n}=\tau$$

where l_n is the length of an element of any dipole in the antenna, $l_{(n+1)}$ is the length of an element in the adjacent smaller dipole and τ is a constant having a value less than *l*, the spacing between said dipoles being given by the formula

$$\frac{\Delta S_{(n+1)}}{\Delta S_n}=\tau$$

where ΔS_n is the spacing between the dipole having the element length l_n and the adjacent larger dipole, $\Delta S_{(n+1)}$ is the spacing between the dipole having the element length l_n and the adjacent smaller dipole, and τ has the significance previously assigned.

7. The antenna of claim 6 wherein τ has a value of about 0.8 to 0.95.

8. The antenna of claim 6 wherein said feeder line conductors are tubular.

9. An aerial system including at least one set of parallel dipoles spaced along and substantially perpendicular to the longitudinal axis of a two-conductor balanced feeder to which the halves of the dipoles are connected at their inner ends, said dipoles being of different electrical lengths increasing substantially logarithmically from the connected end of the feeder to the other end and the dipole feeder connections being crossed over one another between adjacent dipoles, the spacings between which also increase substantially logarithmically from said connected end to the other end.

10. An antenna system for wide-band use comprising a plurality of substantially parallel conducting dipole elements arranged in substantially collinear pairs, the opposite dipole elements of each pair constituting dipole halves, a two-conductor balanced feeder having one conductor connected to each of said elements at substantially the inner end thereof, each of said dipole halves in a pair being connected to a different feeder conductor, adjacent dipole elements being reversely connected to different conductors of the feeder, said dipole elements being selectively spaced along and substantially perpendicular to said feeder, the elements of each pair being of substantially equal length, adjacent dipole elements of different pairs differing in length with respect to each other by a substantially constant scale factor, the selective spacings between adjacent dipoles generally decreasing from one end of the feeder to the other with the greatest spacing being between the longest dipoles, and means to connect the feeder to an external circuit at substantially the location of the smallest of the dipole elements.

11. An antenna system for wide-band use comprising a plurality of substantially parallel conducting dipole elements arranged in substantially collinear pairs, the opposite dipole elements of each pair constituting dipole halves, a two-conductor balanced feeder having one conductor connected to each of said elements at substantially the inner end thereof, each of said dipole halves in a pair being connected to a different feeder conductor, adjacent dipole elements being reversely connected to different conductors of the feeder, said dipole elements being selectively spaced along and substantially perpendicular to said feeder, the elements of each pair being of substantially equal length, adjacent dipole elements of different pairs differing in length with respect to each other by a substantially constant scale factor, the selective spacings between the dipoles along the feeder differing from each other also by a substantially constant scale factor, the greatest spacing being between the longest dipoles, and means to connect the feeder to an external circuit at substantially the location of the smallest of the dipoles.

12. The aerial system of claim 11 in which said scale

factors have values within the range from about 0.8 to about 0.95.

13. An antenna system for wide-band use comprising an array of at least three linear substantially parallel conducting dipoles, each dipole being composed of two opposite substantially collinear conducting elements, a two-conductor balanced feeder having one conductor connected to each of said elements at substantially the inner end thereof, adjacent parallel dipole elements being reversely connected to a different conductor of the feeder, the two elements of each dipole being of substantially equal length and successive elements being of lengths which differ from one dipole to the next by a substantially constant scale factor within the range from about 0.8 to about 0.95, the dipoles being spaced from each other in a generally decreasing manner in the direction of decreasing element length, and means to connect the feeder conductors to an external circuit at substantially the location of the smallest dipole elements.

14. An antenna system for wide-band use comprising a minimum of three pairs of linear substantially parallel conducting elements arranged substantially coplanarly, each pair being substantially collinear and comprising the halves of a dipole, a two-conductor feeder connected to the inner ends of said collinear pairs of elements, adjacent parallel elements being connected to different conductors of the feeder so that the halves of the dipoles connect to different conductors of the feeder and adjacent dipoles are reversely connected, the halves of each dipole being substantially the same length, adjacent dipole elements being selectively spaced from each other along the feeder, the length of the successive dipole elements along the feeder decreasing in accordance with a substantially constant scale factor, each dipole and the feeder between it and the adjacent dipole constituting a cell, the dimension of the several cells measured from the point of connection of one dipole and the feeder to the outer end of the next smaller adjacent dipole also decreasing from one cell to the next in the direction of decreasing dipole length according to a substantially constant scale factor so that the combination of cells provides a substantially uniform wide-band response, and means to connect an external circuit to the feeder elements at substantially the location of the shortest of the dipoles.

15. An antenna system for wide-band use comprising a minimum of three pairs of substantially parallel and coplanar linear conducting elements arranged in substantially collinear pairs, each pair of elements comprising the halves of a dipole, a two-conductor feeder, one conductor of which is connected to each of said elements substantially at the inner end thereof, adjacent parallel elements being connected to different conductors of the feeder so that the halves of the dipoles connect to different conductors of the feeder and adjacent dipoles are reversely connected, the halves of each dipole being substantially the same length, adjacent dipole elements being selectively spaced from each other along the feeder, the lengths of the elements decreasing from one end of the feeder to the other substantially in accordance with a substantially constant scale factor within the range from about 0.8 to 0.95, each dipole and the feeder between it and the adjacent dipole constituting a cell, the cell dimension from the inner end of one dipole to the outer end of the next smaller adjacent dipole also generally decreasing from one cell to the next in the direction from the longer to the shorter dipoles so that the combination of cells provides a substantially uniform wide-band response, and means to connect an external circuit to the feeder elements at substantially the location of the shortest of the dipoles.

References Cited by the Examiner

UNITED STATES PATENTS

2,192,532	3/40	Katzin	343—811
2,507,225	5/50	Scheldorf	343—814 X

FOREIGN PATENTS

1,023,498	1/58	Germany.
408,473	4/34	Great Britain.

HERMAN KARL SAALBACH, *Primary Examiner.*

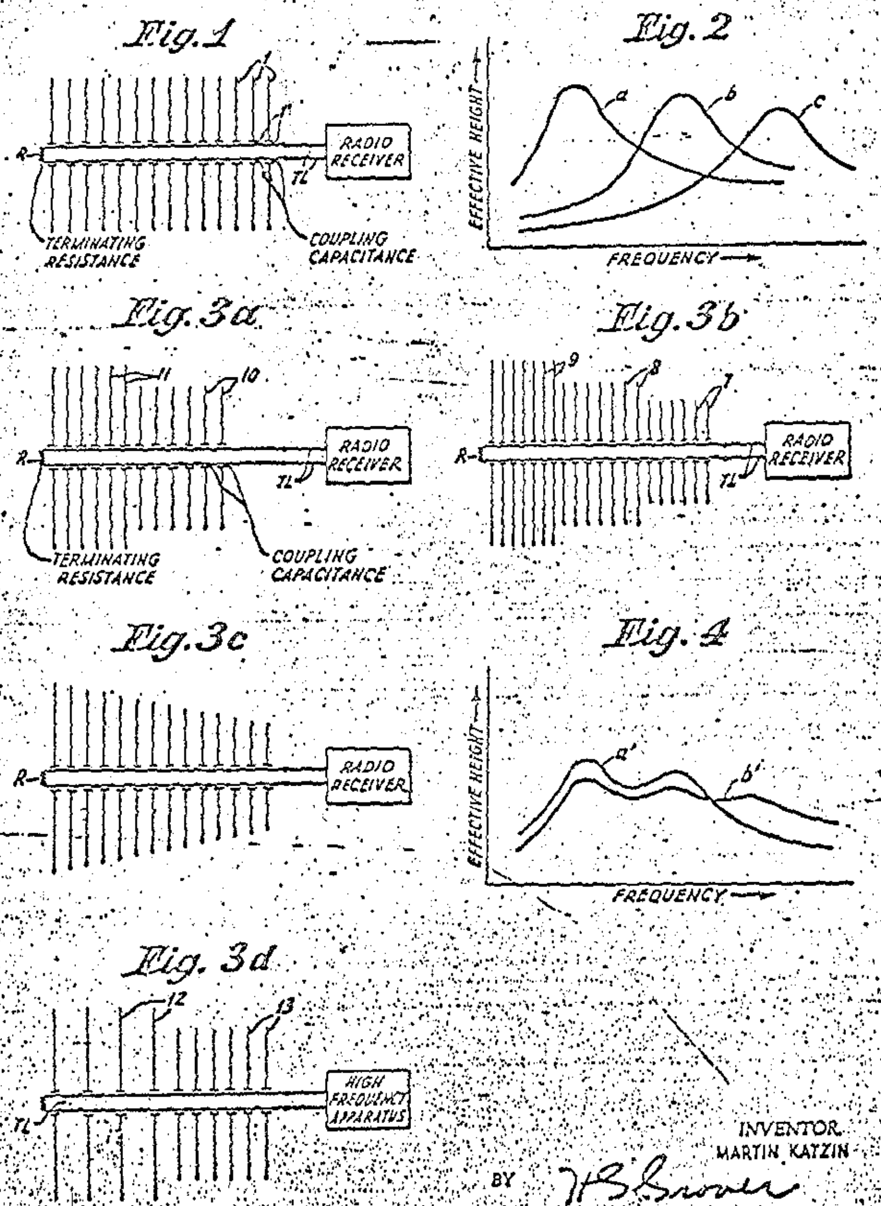
GEORGE N. WESTBY, ELI LIEBERMAN, *Examiners.*

APPENDIX B

March 5, 1940. M. KATZIN 2,192,532

DIRECTIVE ANTENNA

Filed Feb. 3, 1936



INVENTOR
MARTIN KATZIN

BY H. S. Grover

ATTORNEY

DX
E-4

APPENDIX D

June 26, 1934. N. KOOMANS 1,964,189

DIRECTIVE ANTENNA

Filed Sept. 11, 1928

Fig. 1.

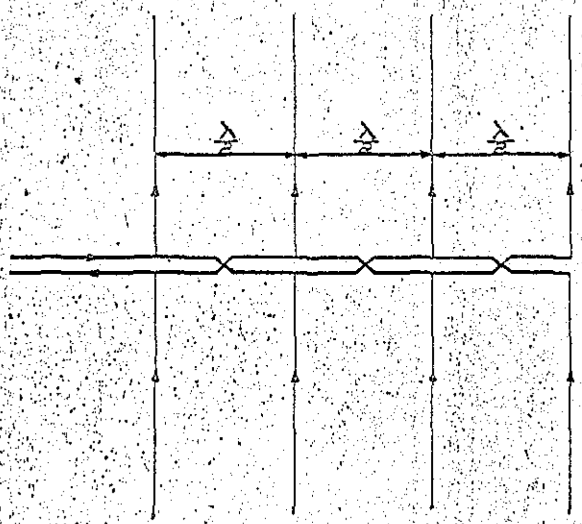
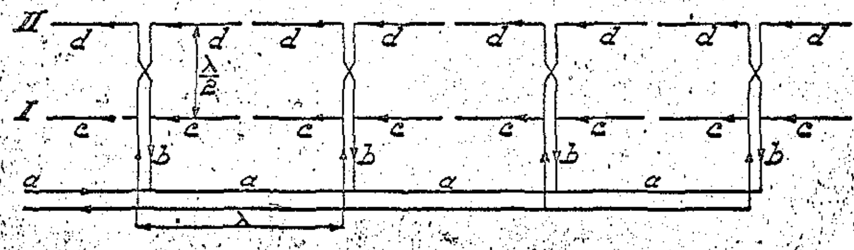


Fig. 2.



Inventor:
N. Koomans

By Langner, Parry, Card & ...
Attys

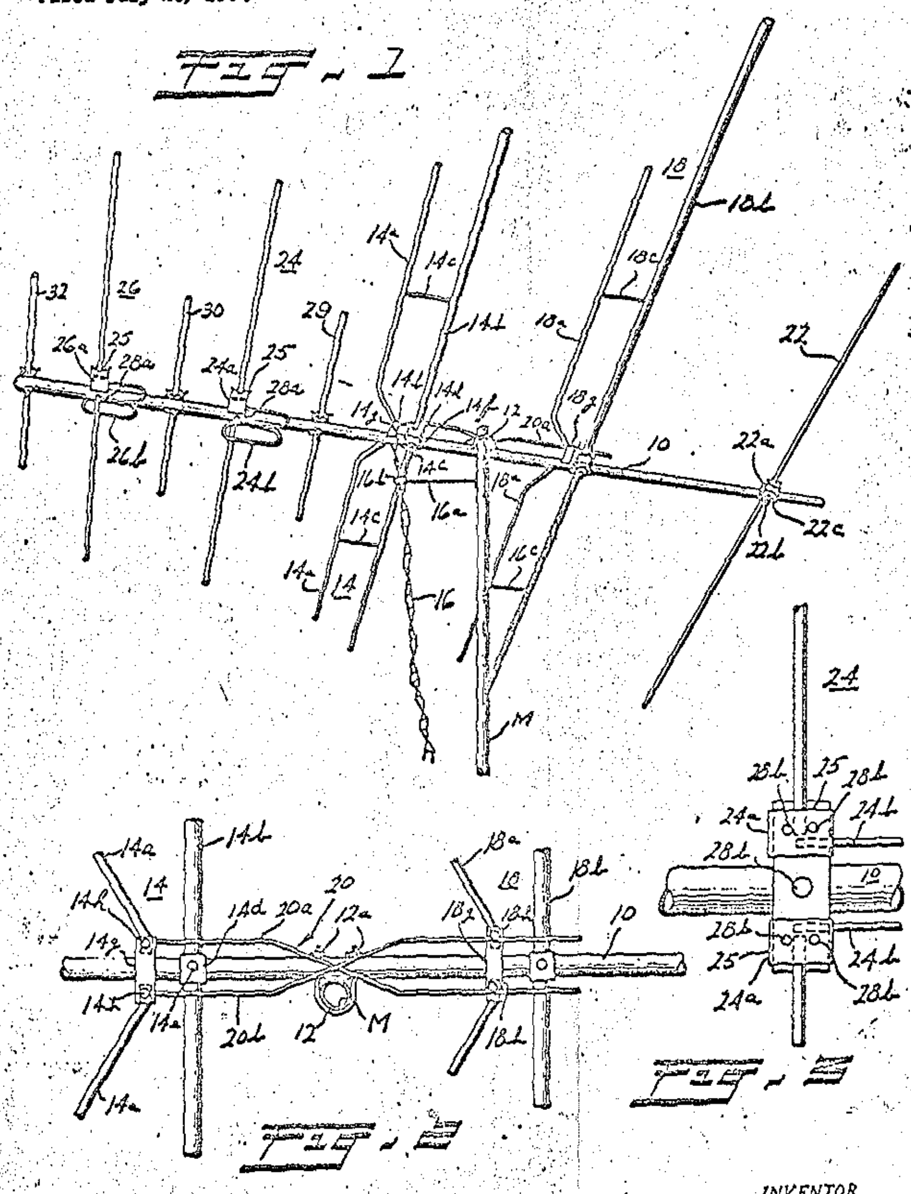
DX
E-1

APPENDIX E

Jan. 18, 1955 J. R. WINEGARD 2,700,105

T. V. ANTENNA ARRAY

Filed July 26, 1954 2 Sheets-Sheet 1



INVENTOR.
John R. Winegard
BY
Baird, Freeman & Molinare
Att'ys.

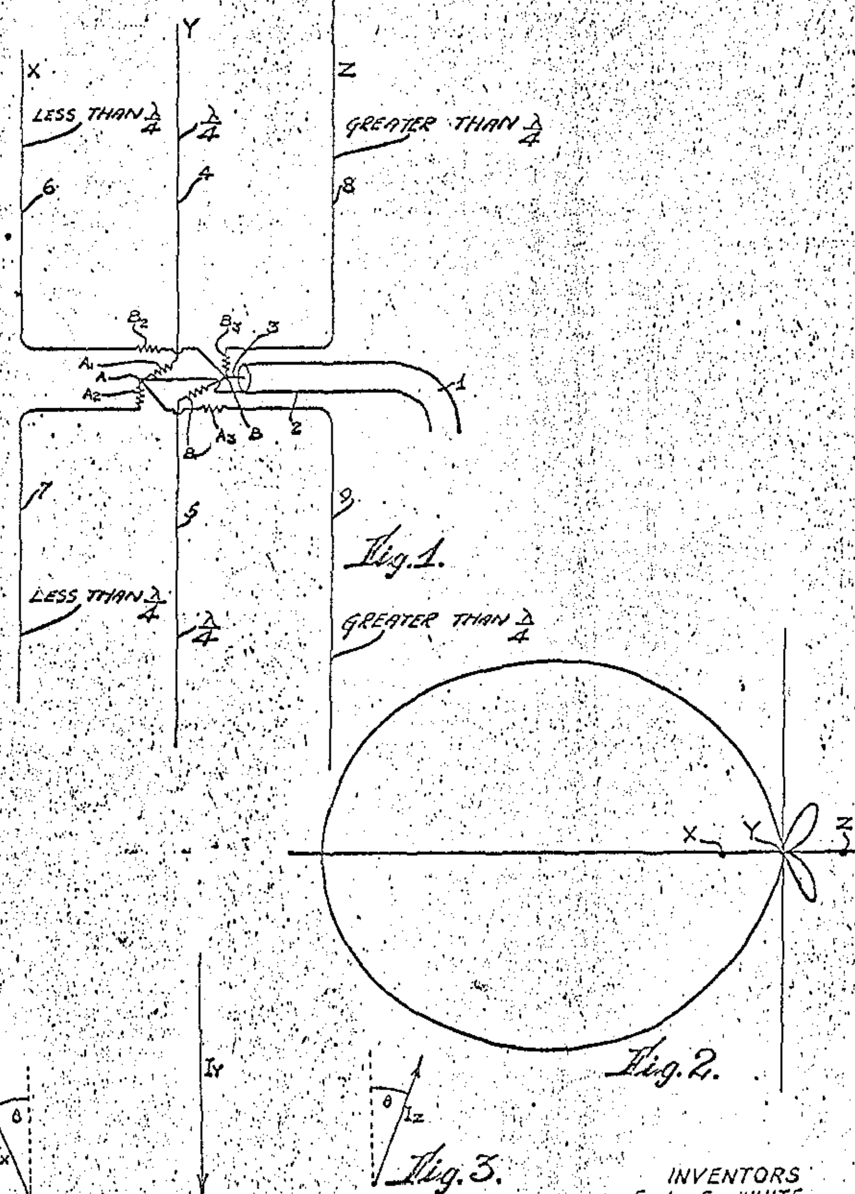
DX
D-1

APPENDIX F

Jan. 18, 1938. E. L. C. WHITE ET AL 2,105,569

DIRECTIONAL WIRELESS AERIAL SYSTEM

Filed April 6, 1936



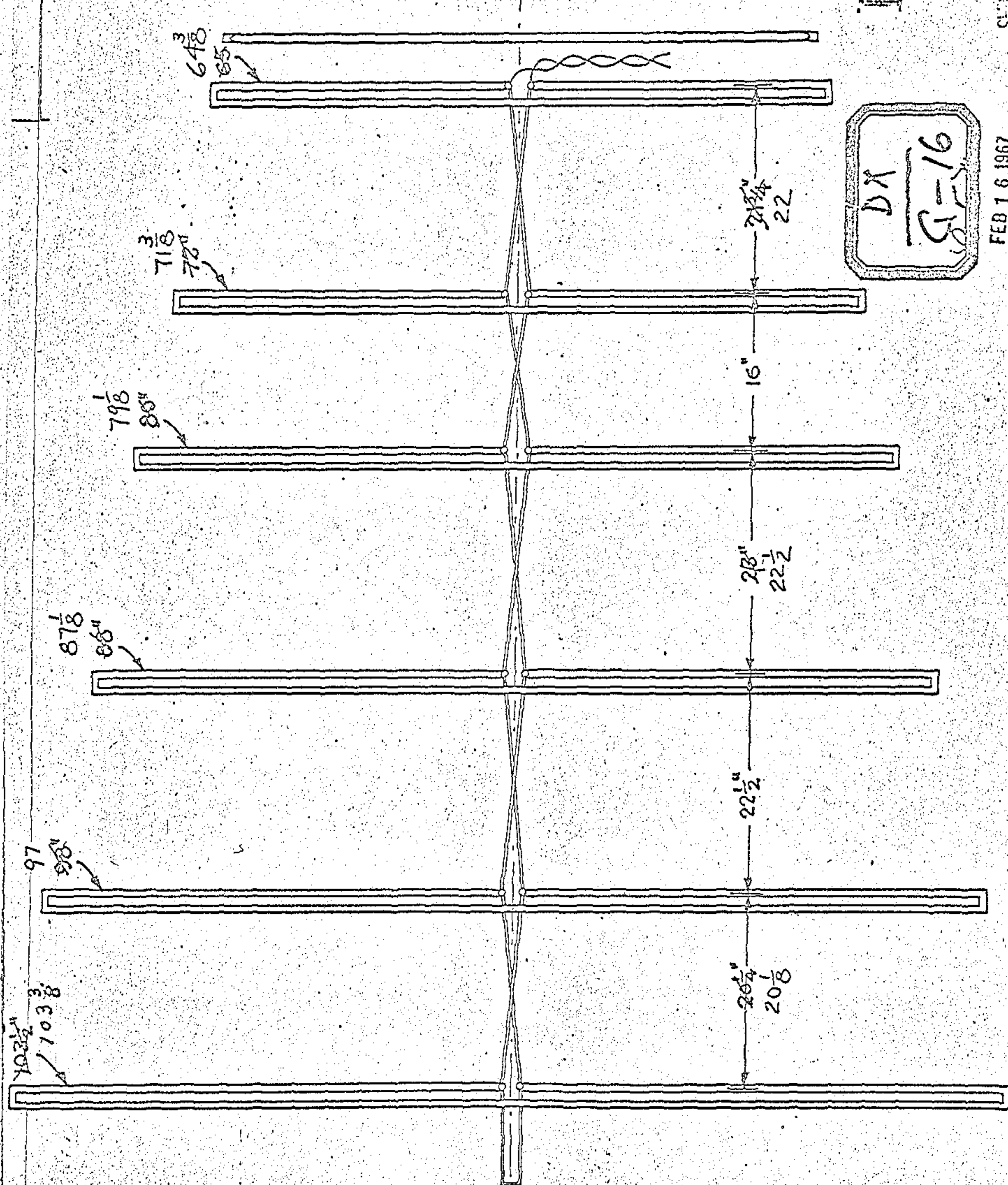
INVENTORS
E. L. C. WHITE
W. S. PERCIVAL

BY H. B. Grover,
ATTORNEY

DX
E-3

APPENDIX C

CHANNEL MASTER
"K.O"-model 1023



BURMEISTER & KULIE

135 SOUTH LA SALLE STREET, CHICAGO, ILLINOIS 60603

MARSHALL A. BURMEISTER
KEITH J. KULIE
DONALD B. SOUTHARD

ATTORNEYS AT LAW - FRANKLIN 2-1344, CENTRAL 6-3351

June 26, 1967

JUN 27 1967
HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD

Richard Phillips, Esq.
Hofgren, Wegner, Allen, Stellman & McCord
20 N. Wacker Drive
Chicago, Illinois

RE: University of Illinois Foundation
-v-
Winegard Company
Our File: 45-34

Dear Dick:

Enclosed is a copy of the decision in the above case. We were a little disappointed not to have a pronouncement on the issue of infringement.

Sincerely yours,

Keith J. Kulie

k

enc.

petitioner did not have a fair and impartial trial as required by the constitutional mandate of "due process of law."

Therefore, the petitioner's application will be denied and the writ cancelled. However, in view of the fact that the petitioner has been released on bail during and pending his appellate proceedings in the state courts, and, also, during and pending this proceeding and determination, the petitioner will be continued on present bail for the further period of thirty (30) days from the date of entry of a final order in this matter to afford the petitioner opportunity to make whatever further applications he may desire.

Counsel will prepare an appropriate Order in accordance with this opinion.

UNIVERSITY OF ILLINOIS FOUNDATION, Plaintiff,

v.

WINEGARD COMPANY, Defendant.

Civ. No. 3-695-D.

United States District Court
S. D. Iowa,
Davenport Division.
June 23, 1967.
As Amended July 18, 1967.

Patent infringement suit in which the validity of the patent was challenged. The District Court, Stephenson, Chief Judge, held that patent No. 3,210,767 entitled "frequency independent unidirectional antennas" was invalid as having been obvious to one ordinarily skilled in the art.

Judgment for defendant.

1. Patents ⟹314

Where defendant in infringement action asserts invalidity of patent as a defense, trial court must determine initially whether the subject of patent is valid. 35 U.S.C.A. § 282.

2. Patents ⟹112(3)

Patent is presumed to be valid from the fact of its issuance. 35 U.S.C.A. § 282.

3. Patents ⟹112(3)

Presumption of validity of issued patent is weakened when there are prior art references or alleged disclosures of patent before trial court that were not considered by the Patent Office during the prosecution of the application for the patent. 35 U.S.C.A. § 282.

4. Patents ⟹18, 37, 46

There are three separate conditions precedent to patent validity: novelty, utility and nonobviousness. 35 U.S.C.A. §§ 101–103.

5. Patents ⟹314

Ultimate question of patent validity is one of law. 35 U.S.C.A. §§ 101–103.

6. Patents ⟹314

In addition to setting out scope of patent in suit, scope and content of prior art must be defined so that a determination can be made as to whether the differences between patent in suit and pertinent prior art would have been obvious to one ordinarily skilled in the art. 35 U.S.C.A. § 103.

7. Patents ⟹18

If differences between patent in suit and pertinent prior art would have been obvious to one ordinarily skilled in the art, the patent would be invalid. 35 U.S.C.A. § 103.

8. Patents ⟹328

Patent No. 3,210,767 entitled "frequency independent unidirectional antennas" was invalid as having been obvious to one ordinarily skilled in the art. 35 U.S.C.A. § 103.

9. Patents ⟹26(1¼)

When one skilled in the art with prior art references before him could have, without exercise of inventive faculty, combined old elements known in the art to produce the plaintiff's "invention", the "invention" does not rise to the level of patentability notwithstanding the fact that it may have been an improvement over the prior art. 35 U.S.C.A. § 103.

10. Patents ⟹226

An invalid patent cannot be infringed. 28 U.S.C.A. § 1338.

Basil P. Mann, William A. Marshall, Chicago, Ill., and David J. Shor, Davenport, Iowa, for plaintiff.

Keith J. Kulie, Donald B. Southard, Chicago, Ill., and Edward W. Dailey, Burlington, Iowa, for defendant.

MEMORANDUM OPINION

STEPHENSON, Chief Judge.

This action was brought by the plaintiff University of Illinois Foundation, the owner by assignment of U. S. Patent 3,210,767, issued to Dwight E. Isbell on October 5, 1965 (hereinafter referred to as the Isbell Patent and attached hereto as Appendix A), against the defendant Winegard Company wherein the plaintiff seeks a finding that said patent has been and is being infringed by the defendant. In its answer the defendant alleges, *inter alia,* invalidity of the patent on the grounds that the invention was disclosed more than one year prior to the date of the application for the patent and that, at the time made, the invention was obvious to one skilled in the art. Jurisdiction is established by virtue of 35 U.S.C. § 281 and 28 U.S.C. § 1338.

[1–3] Inasmuch as the defendant alleges invalidity of the patent as a defense, the Court must determine initially whether or not the Isbell patent is valid. General Mills, Inc. v. Pillsbury Co., 378 F.2d 666 (8th Cir., 1967); American Infra-Red Radiant Co. v. Lambert Indus., Inc., 360 F.2d 977, 983–984 (8th Cir., 1966). Of course, a patent, from the fact of its issuance is presumed to be valid. 35 U.S.C. § 282; Radio Corporation of America v. Radio Engineering Laboratories, Inc., 293 U.S. 1, 7–8, 55 S.Ct. 928, 79 L.Ed. 163 (1934); L & A Products, Inc. v. Britt Tech. Corp., 365 F.2d 83, 86 (8th Cir., 1966); American Infra-Red Radiant Co. v. Lambert Indus., Inc., supra, 360 F.2d at 988–989. However, this presumption of validity is weakened when, as in this case, there are prior art references or alleged disclosures of the patent before the Court that were not considered by the patent office during the prosecution of the application for the patent. Imperial Stone Cutters, Inc. v. Schwartz, 370 F.2d 425, 429 (8th Cir., 1966); American Infra-Red Radiant Co. v. Lambert Indus., Inc., supra, 360 F.2d at 989; Greening Nursery Co. v. J & R Tool & Mfg. Co., 252 F.Supp. 117, 139 (S.D.Iowa, 1966), aff'd, 376 F.2d 738 (8th Cir., 1967).

[4] There are three separate conditions precedent to patent validity. They are: Novelty, utility, and nonobviousness. 35 U.S.C. §§ 101–103; Graham v. John Deere Co., 383 U.S. 1, 12, 86 S.Ct. 684, 15 L.Ed.2d 545 (1966); United States v. Adams, 383 U.S. 39, 48, 86 S.Ct. 708, 15 L.Ed.2d 572 (1966); L & A Products, Inc. v. Britt Tech. Corp., supra, 365 F.2d at 85. In this case the defendant relies on lack of novelty (Title 35 U.S.C. Section 102) and obviousness (Section 103) as barring patentability. It is the opinion of the Court that the issue of obviousness is dispositive of this case. Therefore, that issue will be first considered.

[5–7] While the ultimate question of patent validity is one of law, the determination of the question of obviousness lends itself to several basic factual inquiries. Graham v. John Deere Co., supra, 383 U.S. at 17, 86 S.Ct. 684; L & A Products, Inc. v. Britt Tech. Corp., supra, 365 F.2d at 86. In addition to setting out the scope of the patent in suit, the scope and content of the prior art must be defined so that a determination can be made as to whether the differences between the patent in suit and the pertinent prior art would have been obvious to one ordinarily skilled in the art. If such differences as may exist would have been obvious to a person ordinarily skilled in the art, the obviousness test of 35 U.S.C. § 103 has not been 6 met and the patent will be invalid. Graham v. John Deere Co., supra, 383 U.S. at 37, 86 S.Ct. 684, General Mills, Inc. v. Pillsbury Co., supra.

The Patent in Suit

The Isbell Patent is entitled "Frequency Independent Unidirectional Antennas" and relates to antennas designed for the transmission and reception of electromagnetic radio frequency signals. These signals are used for the broadcasting of many types of communications including radio and television signals. The Isbell antenna consists of a plurality of elements called "dipoles"[1] which are a ranged in relation to each other and co nected to each other in a particular ma ner. Generally, as stated in the pate specification, "the antennas of the i vention are coplanar dipole arrays co sisting of a number of dipoles arrang in side-by-side relationship in a plane, t length and the spacing between succe sive dipoles varying according to a def nite mathematical formula, each of th dipoles being fed by a common feede (transmission line) * * *."[2] Accor ing to the patent specification,

The feeder or transmission line co sists of two conductors, one of which connected to the inner end of one-ha of each dipole, the other being connecte

The lengths of the dipoles and the spacing between dipoles are related bv a constant scale factor τ defined by the following equations:

$$\tau = \frac{L(n+1)}{Ln} = \frac{\Delta S(n+1)}{\Delta Sn}$$

where τ is a constant having a value less than 1, Ln is the length of any intermediate dipole in the array, L(n+1) is the length of the adjacent smaller dipole, ΔSn is the spacing beween the dipole having the length Ln and the adjacent larger dipole, and Δ S(n+1) is the spacing between the dipole having the length Ln and the adjacent smaller dipole.[3]

1. Generally, in this context, a simple straight dipole antenna element consists of two elongated metallic conductors (wires, rods or tubes) arranged approximately colinearly in such a manner that there is a small gap or terminal between their inner ends, at which point a transmission line is attached. The familiar "rabbit-ear" indoor television antenna is a simple dipole having its arms at an angle rather than in a straight line. When immersed in an electromagnetic field the dipole element will intercept electromagnetic radio waves and produce a voltage across the terminal. This voltage is carried to the receiver by means of the transmission line. The dipole antenna element, like any other electrical conductor, will intercept radio energy from the atmosphere to a limited extent, regardless of the frequency of the energy being transmitted. There is, however, a special condition, known as "resonance", in which the dipole is strongly receptive, which occurs when the dipole is of a particular length in relationship to the wavelength of the radiated energy. This condition occurs primarily when the overall length of the dipole is one-half of the wavelength of the radio wave. Thus, it is apparent that a dipole can be "tuned" for optimum reception of a particular radiowave frequency by adjusting the overall length of the dipole. The relative ability of one antenna to produce a signal (i.e., a radio frequency voltage) at a given location distant from the transmitting station in comparison with another antenna similarly located is a measure of the antenna's "gain," a technical term used in the industry in reference to an antenna's signal-producing capabilities.

2. Isbell Patent, Col. 1, lines 14–19. See App. A.

3. Isbell Patent, Col. 1, lines 50–62. See App. A

he inner end of the other h
ole, and transposed betwee
ns of successive dipoles i
nner that each conductor is
rnately to the left and ri
successive dipoles. (See
Fig. 1.)

Antennas designed in accor
patent specifications are
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lly independent of the fr
e electromagnetic radio w
nsmitted or received. A
th such characteristics is
sirable when the receptio
fferent frequencies is r
e such antenna may b
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frequencies. Since VH
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16 megacycles/second,[4] an
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Channels 2–6 broadcast ov
frequencies 54–88 mega
each channel being assign
megacycles wide in which
Thus, channel 2 broadcas
range 54–59 megacycles/sec
3, 60–65 megacycles/second
nels 7–13 broadcast ove
176–216 megacycles/second

5. The Winegard an
patent are the mod
Chromafle
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6.

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as stated in the patent
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ber of dipoles arranged
lationship in a plane, the
spacing between succes-
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al formula, each of the
d by a common feeder
ie) * * *."[2] Accord-
specification,

transmission line con-
ductors, one of which is
ie inner end of one-half
the other being connected

ween dipoles are
e following equa-

Ln is the length
the length of the
n the dipole, hav-
nd Δ S(n+1) is
and the adjacent

n occurs when the dipole
lar length in relationship
th of the radiated energy.
occurs primarily when the
of the dipole is one-half
ngth of the radio wave.
rent that a dipole can be
imum reception of a par-
ve frequency by adjusting
th of the dipole. The rel-
one antenna to produce a
adio frequency voltage) at
n distant from the trans-
in comparison with an-
imilarly located is a meas-
enna's "gain," a technical
the industry in reference
's signal-producing capa-

Col. 1, lines 14–19. See

Col. 1, lines 50–62. See

to the inner end of the other half of the dipole, and transposed between connections of successive dipoles in such a manner that each conductor is connected alternately to the left and right halves of successive dipoles. (See Appendix A, Fig. 1.)

Antennas designed in accordance with the patent specifications are claimed to have unidirectional radiation patterns and high quality performance which are, over a wide band of frequencies, essentially independent of the frequency of the electromagnetic radio waves being transmitted or received. An antenna with such characteristics is, of course, desirable when the reception of many different frequencies is required as one such antenna may be used in place of many antennas which are each capable of receiving a limited number of frequencies. Since VHF television signals are broadcast over a range of frequencies of 54 megacycles/second to 216 megacycles/second,[4] an antenna capable of receiving high quality signals with uniform performance characteristics in that range of frequencies would be of commercial utility. This is particularly true in respect to the reception of color television signals where the minimum standards of performance are higher than those required for satisfactory black and white television reception.

There are fifteen claims in the Isbell patent. See Appendix A. All of the claims except numbers 6, 7 and 8 are claimed to be infringed by one or more of twenty-two models of defendant's antennas which are designed for the reception of television signals.[5] Specifically, all twenty-two models are alleged to be literal infringements of claims 14 and 15 and also within the inventive concept of claims 1–5 and 9–13. In addition, one of the antennas, the chromatel CT–100, is alleged to be a literal infringement of claims 1, 2, 9, 10, 11, and 12. It should be noted here that while the portions of the antennas which are charged as infringing are designed solely for the reception of VHF television signals, the Isbell antenna is not so limited. It is designed both as a receiving antenna and a transmitting antenna for use in an unlimited range of frequencies. For example, the specification indicates that the antenna has very high performance characteristics over as high a range as 1100 to 1800 mc/sec.[6]

4. Channels 2–6 broadcast over radiowave frequencies 54–88 megacycles/second, each channel being assigned a band 6 megacycles wide in which to broadcast. Thus, channel 2 broadcasts over the range 54–59 megacycles/second; channel 3, 60–65 megacycles/second; etc. Channels 7–13 broadcast over frequencies 176–216 megacycles/second, with 89–175 megacycles/second being assigned to non-television broadcasting. While some of the antennas accused of infringing are designed for the reception of VHF and UHF (470–890 megacycles/second) signals, it is only the VHF sections of these antennas that are alleged to be infringements of the Isbell patent.

5. The Winegard antennas that are alleged to be infringements of the Isbell patent are the models with the following numbers:

Chromaflex	B–445	R.C.A.	10–B–200
"	B–550	"	10–B–300
"	B–555	"	10–B–400
"	B–660	"	10–B–1010
"	B–770	"	10–B–1020
"	B–105	"	10–B–1030
"	B–335	"	10–B–1040
Chromatel	CT–40	"	10–B–1050
"	CT–80	"	10–B–1120
"	CT–90	"	10–B–1130
"	CT–100	"	10–B–1140

6. Isbell Patent, Col. 2, lines 47–52. See App. A.

Prior Art

Four prior patents are cited in the patent as having been considered by the patent examiners. One of these patents, five other U. S. patents not referred to by the examiners, an article published on March 31, 1958 and three antennas in use prior to 1959 are among the references relied upon by the defendant as revealing the prior art at the time of the invention. An examination of some of these references will be helpful in defining the state of the prior art on May 3, 1960, the date of the filing of the application for the patent.

The Katzin patent (U. S. Patent No. 2,192,532, the first page of which is attached hereto as Appendix B) cited by the patent office reveals an antenna consisting of an array of dipole elements of different lengths arranged in a side-by-side relationship in a plane. While some of the illustrated embodiments of the Katzin invention show antennas having several elements of one length arranged parallel to several elements of another length, one illustrated embodiment (Figure 3c, Appendix B) shows an array described in claim 7 of the patent as being "a plurality of aerial elements, all of differing length, continuously tapering in length from one end of said antenna to the other * * *."[7] The patent also suggests, in claim 11 thereof, that the spacing between the shorter elements may be less than that between the longer elements.[8] The teaching of the Katzin patent is that if elements, or groups of elements, of differing lengths are combined into one array, each of the elements, or groups of elements, "will respond most efficiently to its corresponding band of frequencies, so that the combination of two or more such groups * * * will give the result of a high response for a wider frequency band."[9]

One of the antennas cited as prior art by the defendant is the Channel Master "K. O." antenna model 1023, produced and marketed by the Channel Master Corporation at Ellenville, N. Y. between September 1954 and December 1958. A schematic diagram of this antenna, Exhibit DX–G–16, is attached hereto as Appendix C. This antenna is an array of *folded* dipoles,[10] each of a different length, arranged in a coplanar side-by-side relationship decreasing in length from one end of the array to the other. The spacing between the dipole elements is irregular, the elements not being equally spaced and the spacing not varying progressively from one end of the array to the other. The feeder or transmission line running between the elements consists of two conductors, one of which is connected to one end of the folded dipole at the terminal point, the other connected to the other end of the dipole at the terminal point, and transposed between dipoles such that each conductor is alternately connected to the left and right ends of successive dipoles. Trans-

7. U.S. Patent No. 2,192,532, p. 2, Col. 2, lines 54–58.

8. U.S. Patent No. 2,192,532, p. 3, Col. 2, lines 5–14; See also Fig. 3d, App. B.

9. U.S. Patent No. 2,192,532, p. 2, Col. 1, lines 16–21.

10. Folded dipoles are simple dipoles, see n. 1, supra, which have been altered by adding another conductor in such a manner that it is approximately parallel to the simple dipole and attached to the outer ends of each half of the simple dipole. The resulting structure is an elongated loop having a terminal point midway along one of its longer sides. (See App. C) Folded dipoles have somewhat different characteristics than straight or simple dipoles, the primary differences being that folded dipoles have better performance over a greater bandwidth of frequencies and that folded dipoles have a greater resistance to the flow of electric current than do simple dipoles. This resistance to the flow of current is known as "impedence." In order to achieve the maximum transmission of the signal to the receiver, the impedence of the antenna, the transmission line and the receiver should be as nearly equal as possible. Television transmission line and receivers have an impedence set by FCC regulation at about 300 ohms. A simple dipole has an impedence of about 75 ohms while a folded dipole has an impedence of about 300 ohms.

posed feeder lines are also shown in the Koomans Patent (U. S. Patent No. 1,-934,189, the first page of which is attached hereto as Appendix D) and the Winegard Patent (U. S. Patent No. 2,-700,105, the first page of which is attached hereto as Appendix E), both of which are cited as prior art by the defendant. The White Patent (U. S. Patent No. 2,105,569, the first page of which is attached hereto as Appendix F) also uses transposed feeder lines in conjunction with dipole elements *decreasing in* length from one end of the array to the other. However, the White array is "center-fed," that *is, connected* to the down lead transmission line which leads to the receiver, at the center of the array, *rather* than at the end of the array. The antennas described in the Katzin, Koomans, and Winegard patents *noted* above and the "K. O." antenna, as well as the Isbell antenna, are all fed at the end of the antenna *having* the smaller elements.

The article cited by the defendant Winegard as prior art is "Logarithmically Periodic Antenna Designs" published by R. H. DuHamel and F. R. Ore on March 31, 1958. *This article explains* the elements of the theory of logarithmically periodic (log periodic) antennas and the *development* of several such antennas. Generally stated, log periodic antennas are designed according to the theory that an antenna "design cell"[11] having high performance characteristics for reception of a limited band or *period* of radio frequency signals, if altered in all dimensions by a constant scale factor will have high performance *characteristics* for reception of a band of signals having wavelengths which vary from the wavelengths of *the* first band of frequencies by the same constant scale factor. Thus, according to the theory, if an antenna *design cell* has certain characteristics for reception of particular frequency wavelengths, an antenna geometrically *similar* but reduced in all dimensions by a scale factor of .5 will have similar characteristics for reception of frequencies of wavelengths half those of the first. The theory continues that if a particular design cell is reduced successively by a constant scale factor which is less than 1, and repeated periodically in one antenna *"array"*, the array will have the characteristics of the design cell over a broader band of frequencies which is *limited only* by the largest and smallest of the geometrically similar design cells which are repeated in the array. Because the performance of the antennas so designed is theoretically the same over any band of frequencies *for which* the antenna is designed the antennas are termed Frequency Independent Antennas. The application of this theory to antenna design appears to be limited only by the conditions that the design cell used must have uniform performance *over a single* period and that the overall array, the periodic repetition of the cell, not cause an "end effect"[12] that would *destroy* the frequency independence of the array.

The formula set out by DuHamel and Ore as defining the *relationship* be-

11. The term "design cell" is used herein to refer to a structural unit of an antenna which is capable of receiving and transmitting electromagnetic radio energy. A simple or folded dipole and an adjacent section of transmission line are examples of such antenna design cells. A particular antenna array may be composed of one or more similar or dissimilar design cells.

12. Very generally stated, "end effect" is a term used *to describe a* bouncing back and forth, from one end of an antenna array to the other, of any energy that is not fully transmitted *or* absorbed by the elements of the antenna as the energy travels initially *along the antenna.* This bouncing, or reflection, back and forth may cause shadows or *ghosts in the* reception of a television picture. Thus, in order to avoid this end effect *an antenna* should be designed to have sufficient elements to radiate or absorb *all* of the energy as it passes from one end of the antenna to the other so that there *will* be no such reflection of the energy back down the antenna.

tween the repeated, or periodic, design cells is: $\tau = \frac{R_{n+1}}{R_n}$, which defines a constant proportional relationship between like elements of the design. In this case the formula relates to the radii of circular structures. Of course, in the case of goeometrically similar designs all dimensions of one design are proportionally equal to all dimensions of the other similar designs. That is, they must all vary proportionally. The theory of the log periodic antenna was adopted by Isbell in his work and the formula, $\tau = \frac{L(n+1)}{L_n} = \frac{\Delta S(n+1)}{\Delta S_n}$ where τ is a constant having a value of less than 1, can be seen to be a simple adaptation of the DuHamel-Ore formula [13] and its mathematical equivalent.

The Invalidity of the Patent

Keeping in mind the prior art previously discussed, it can be seen that an antenna with the general parameters of the Isbell Patent will result from a combination of the dipole array of Katzin with the transposed feeder line of the Channel Master "K. O." or the Koomans or Winegard Patents. Such an antenna would consist of a coplanar side-by-side array of straight dipole elements of differing lengths which decrease in length and spacing from one end of the array to the other (as disclosed by claims 7 and 11 of the Katzin patent), fed at the small end of the array by a two conductor transmission line that is transposed between successive elements (as disclosed by the Koomans and Winegard Patents and the Channel Master "K. O." antenna). Further, if the length and spacing of the dipole elements in such an antenna are adjusted by the log periodic theory of antenna design which dictates that the periodic or repeating cells (here a dipole element and adjoining section of transmission line) shall be geometrically similar and related to each other in size by a constant scale factor, the result is the Isbell antenna disclosure. It is thus apparent that the Isbell antenna is a combination of elements, all known in the prior art and also that these known elements were combined in the Isbell antenna in a manner dictated by a theory also known in the prior art. Therefore, the critical question is whether such a combination would have been obvious to one reasonably skilled in the art of antenna design. United States v. Adams, supra, 383 U.S. at 50–52, 86 S.Ct. 708, 15 L.Ed.2d 572; Kell-Dot Indus., Inc. v. Graves, 361 F.2d 25, 30 (8th Cir., 1966); American Infra-Red Radiant Co. v. Lambert Indus., Inc., supra, 360 F.2d at 988. Those skilled in the art at the time of the Isbell application knew (1) the log periodic method of designing frequency independent antennas, (2) that antenna arrays consisting of straight dipoles with progressively varied lengths and spacings exhibit greater broad band characteristics than those consisting of dipoles of equal length and spacing and, (3) that a dipole array type antenna having elements spaced less than ½ wavelength apart could be made unidirectional in

13. While DuHamel and Ore defined circular structures by relating the radii of different parts of one cell to the radii of another, Isbell has defined linear structures by relating the lengths and spacings of one design cell to another. That these are alternative means of expressing the same mathematical relationship is evident from an examination of Figure 1 of the Isbell patent and the discussion, found in Col. 1, line 63 to Col. 2, line 2 of the patent, relative to the distance from the base line O, in Figure 1, to the dipole having the length Ln. If the distance from the base line O to dipole having the length Ln were the radius of a circle having its axis at line O and its circumference tangent to the same dipole, the distance represented by Xn ("the distance from the base line O to the dipole having the length Ln", see Col. 1, lines 71–72 of Appendix A) would be equal to Rn, where Rn is the radius of the said circle having its axis at O and its circumference tangent to the dipole of length Ln; then, it is easily seen that the formulas $\tau = \frac{R_{n+1}}{R_n}$ (Isbell) and $\tau = \frac{X(n+1)}{X_n}$ (DuHamel & Ore) are different but equal mathematical expressions of the same proportional relationship.

radiation pattern by t feeder line between eleme the array at the end of t ment.

[8, 9] It is the opinic that it would have been ordinarily skilled in the a to design a frequency ind rectional antenna to coml old elements, all suggest art references previou The test of obviousness is to be applied in determi new combination of knc patentable. American In Co. v. Lambert Indus., F.2d at 988. When one s with the prior art refere could have, without the ventive faculty, combin known in the art to pr tiff's "invention," the not rise to the level of p

14. It should also be noted Wrapper of the Isbell p that on November 9, 1960 claims (final claims 1–S never approved) were in by examiner G. N. Westb by Katzin (Patent No. 2 C) in view of other paten crossing of the feeder li of straight tubular conduc 10, 1961, Isbell submitted to the Patent Office whe that
"there is certainly no gestion in the Katzin rangement in which *bo* successive dipoles *and* tween said dipoles va *such that the ratio c adjacent dipoles is a is also equal to the r ings between adjacen* less both of these coi the antenna does not l ably wide band paths, t

radiation pattern by transposing the feeder line between elements and feeding the array at the end of the smallest element.

[8, 9] It is the opinion of the Court that it would have been obvious to one ordinarily skilled in the art and wishing to design a frequency independent unidirectional antenna to combine these three old elements, all suggested by the prior art references previously discussed.[14] The test of obviousness is the proper test to be applied in determining whether a new combination of known elements is patentable. American Infra-Red Radiant Co. v. Lambert Indus., Inc., supra, 360 F.2d at 988. When one skilled in the art with the prior art references before him could have, without the exercise of inventive faculty, combined old elements known in the art to produce the plaintiff's "invention," the "invention" does not rise to the level of patentability notwithstanding the fact that it may be an improvement over the prior art. Kell-Dot Indus., Inc. v. Graves, supra, 361 F.2d at 29. The Court, upon full consideration of the record herein, finds that the disclosure of Isbell's Patent No. 3,210,767 is lacking in the prerequisite nonobviousness and is, therefore, invalid.

[10] Inasmuch as an invalid patent cannot be infringed Imperial Stone Cutters, Inc. v. Schwartz, supra, 370 F.2d at 429; Kell-Dot Indus., Inc. v. Graves, supra, 361 F.2d at 28, the question of infringement is rendered moot and is, therefore, not decided by this Court.

The foregoing shall constitute the findings of fact and conclusions of law pursuant to Fed.R.Civ.P. 52(a).

It is ordered that judgment will be entered for the defendant with costs, exclusive of attorney's fees, taxed to the plaintiff.

14. It should also be noted that the File Wrapper of the Isbell patent indicates that on November 9, 1960, all original 9 claims (final claims 1–8 and another never approved) were initially rejected by examiner G. N. Westby as being met by Katzin (Patent No. 2,192,532, App. C) in view of other patents teaching the crossing of the feeder line and the use of straight tubular conductors. On May 10, 1961, Isbell submitted an amendment to the Patent Office wherein he argued that

"there is certainly no teaching or suggestion in the Katzin patent of an arrangement in which *both* the length of successive dipoles *and* the spacing between said dipoles vary in a manner *such that the ratio of the length of adjacent dipoles is a constant which is also equal to the ratio of the spacings between adjacent dipoles.* Unless both of these conditions are met the antenna does not have the remarkably wide band paths, the high gain and the directivity exhibited by the antennas of the invention." (Emphasis in the original).

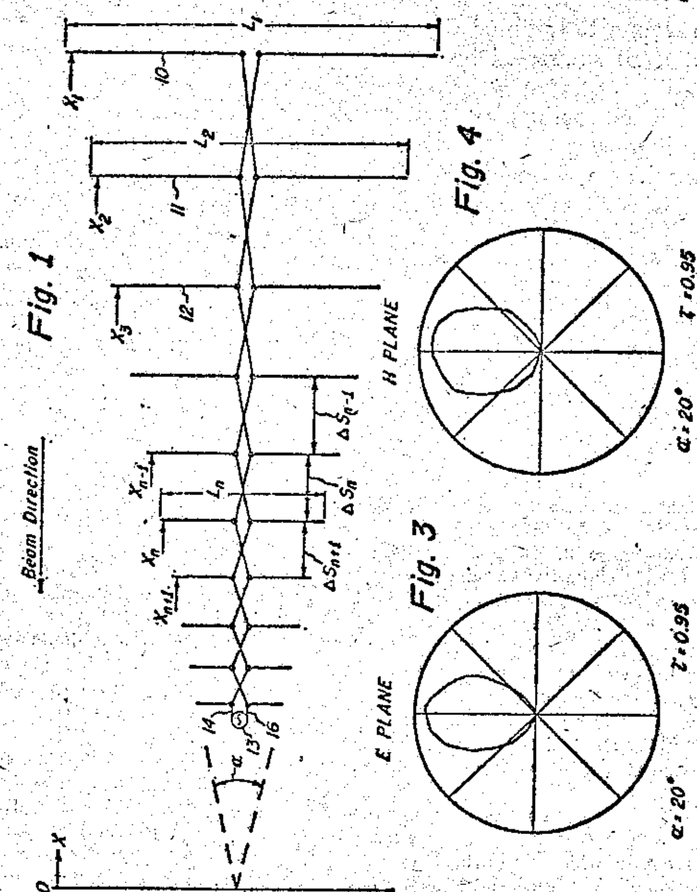
Subsequently, original claims 1–8 were allowed by examiners H. K. Saalbach and Eli Lieberman as were 7 additional claims added as a result of an interference proceeding and further amendments by the applicant. It appears, thus, that the above argument in regard to the constant proportional relationship of the lengths and spacings of the elements and the importance of such relationship convinced the Patent Office that the Isbell disclosure was patentable. However, there is nothing in the file wrapper to indicate that, in ruling on the patentability of the Isbell patent, the patent examiners considered the published work of DuHamel and Ore, the formula set out therein, or the log periodic theory of antenna design all of which was a part of the prior art at the time of the application. Reference was made thereto in the interference proceedings as indicated in PX–68.

APPENDIX A

Oct. 5, 1965 D. E. ISBELL 3,210,767

FREQUENCY INDEPENDENT UNIDIRECTIONAL ANTENNAS

Filed May 3, 1960 2 Sheets-Sheet 1



INVENTOR.
Dwight E. Isbell

BY

Merriam, Smith & Marshall
ATTORNEYS

DIX A

ISBELL 3,210,767

UNIDIRECTIONAL ANTENNAS

2 Sheets-Sheet 1

Fig. 4

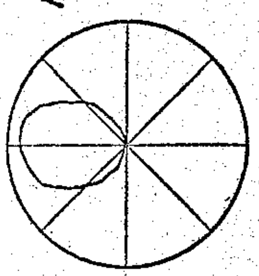
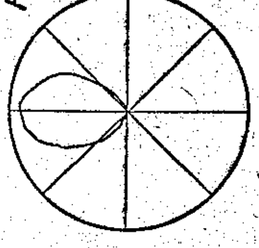


Fig. 3



INVENTOR.
Dwight E. Isbell
BY
Merriam, Smith & Marshall
ATTORNEYS

Oct. 5, 1965 D. E. ISBELL 3,210,767

FREQUENCY INDEPENDENT UNIDIRECTIONAL ANTENNAS

Filed May 3, 1960 2 Sheets-Sheet 2

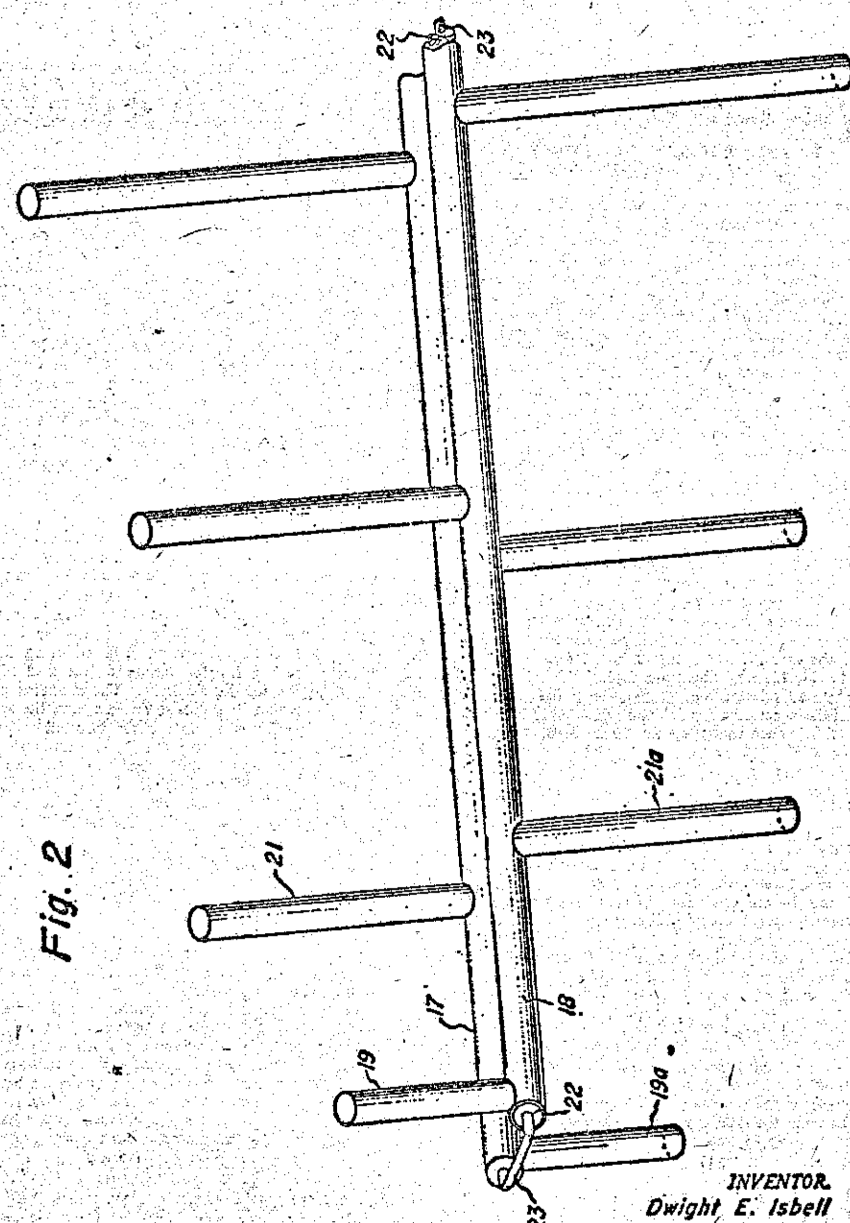


Fig. 2

INVENTOR.
Dwight E. Isbell
BY
Merriam, Smith & Marshall
ATTORNEYS

United States Patent Office

3,210,767
Patented Oct. 5, 1965

1

3,210,767
FREQUENCY INDEPENDENT UNIDIRECTIONAL ANTENNAS

Dwight E. Isbell, Seattle, Wash., assignor to The University of Illinois Foundation, a non-profit corporation of Illinois

Filed May 3, 1960, Ser. No. 26,589
15 Claims. (Cl. 343—792.5)

This invention relates to antennas, and more particularly, it relates to antennas having unidirectional radiation patterns that are essentially independent of frequency over wide bandwidths.

The antennas of the invention are coplanar dipole arrays consisting of a number of dipoles arranged in side-by-side relationship in a plane, the length and the spacing between successive dipoles varying according to a definite mathematical formula, each of the dipoles being fed by a common feeder which introduces a phase reversal of 180° between connections to successive dipoles. The antennas of the invention provide unidirectional radiation patterns of constant beamwidth and nearly constant input impedances over any desired bandwidth.

The invention will be better understood from the following detailed description thereof taken in conjunction with the accompanying drawing, in which:

FIGURE 1 is a schematic plan view of an antenna made in accordance with the principles of the invention;

FIGURE 2 is an isometric view of a practical antenna embodying the invention; and

FIGURES 3 and 4 are radiation patterns of a typical antenna, in the E plane and H plane, respectively.

Referring to FIGURE 1, it will be seen that the antenna of the invention was composed of a plurality of dipoles 10, 11, 12, etc., which are coplanar and in parallel, side-by-side relationship. It will be noted that the lengths of the successive dipoles and the spacing between these dipoles is such that the ends of the dipoles fall on a pair of straight lines which intersect and form an angle α. In the preferred embodiment the antenna is symmetrical about a line passing through the midpoints of the dipoles, as shown.

The antenna is fed at its narrow end from a conventional source of energy, depicted in FIGURE 1 by alternator 13, by means of a balanced feeder line consisting of conductors 14 and 16. It will be seen that the feeder lines 14 and 16 are alternated between connections to consecutive dipoles, thereby producing a phase reversal between such connections.

The lengths of the dipoles and the spacing between dipoles are related by a constant scale factor τ defined by the following equations:

$$\tau=\frac{L_{(n+1)}}{L_n}=\frac{\Delta S_{(n+1)}}{\Delta S_n}$$

where τ is a constant having a value less than 1, L_n is the length of any intermediate dipole in the array, $L_{(n+1)}$ is the length of the adjacent smaller dipole, ΔS_n is the spacing between the dipole having the length L_n and the adjacent larger dipole, and $\Delta S_{(n+1)}$ is the spacing between the dipole having the length L_n and the adjacent smaller dipole.

It will be seen from the geometry of the antennas, as given above, that the distance from the base line 0 at the vertex of the angle α to the dipoles forming the array are defined by the equation:

$$\tau=\frac{X_{(n+1)}}{X_n}$$

where X_n is the distance from the base line 0 to the dipole having the length L_n, $X_{(n+1)}$ is the corresponding distance

2

from the base line to the adjacent smaller dipole, and τ has the significance previously given.

The radiation pattern of the antennas of the invention, having the geometrical relationship among the several parts as defined above, is unidirectional in the negative X direction, i.e., extending to the left from the narrow end of the antenna of FIGURE 1.

The construction of an actual antenna made in accordance with the invention is shown in FIGURE 2. In this antenna the balanced line consists of two closely-spaced and parallel electrically conducting small diameter tubes 17 and 18 to which are attached the dipoles, each of which consists of two individual dipole elements, e.g., 19 and 19*a*, 21 and 21*a*, etc. It will be noted that each of the two elements making up one dipole is connected to a different one of said conductors 17 and 18, in a direction perpendicular to the plane determined by said conductors 17 and 18. Moreover, considering either one of the conductors 17 and 18, consecutive dipole elements along the length thereof extend in opposite directions. It will be seen that this construction has the effect of alternating the phase of the connection between successive dipoles, as depicted schematically in FIGURE 1. Although the dipoles of FIGURE 2 are not precisely coplanar, differing therefrom by the distance between the parallel conductors, in practice this distance is very small so that the dipole elements are substantially coplanar and the advantages of the invention are maintained. The antenna of FIGURE 2 may be conveniently fed by means of a coaxial cable 22 positioned within conductor 18, the central conductor 23 thereof extending to and making electrical connection with conductor 17 as shown.

As an example of the invention, an antenna of the type shown in FIGURE 2 was constructed using 0.125 inch diameter tubing for the balanced line and 0.050 inch diameter wire for the elements. The elements were attached to the feeder line with soft solder, and the array was fed with miniature coaxial cable inserted through one of the balanced line conductors. The antenna was defined by the parameters $\tau=0.95$ and $\alpha=20°$. The antenna had a total of 15 dipoles, with the longest dipole element being 2½" long, while the shortest element was one-half of this length, or 1¼". The array was 7½" long.

Typical radiation patterns for the above-described antenna in the E plane and the H plane are shown in FIGURES 3 and 4, respectively. These patterns were found to remain essentially constant over the band of about 1100 to 1800 mc./sec. The minimum front-to-back ratio over this band was 17 db and the directivity over the range from about 1130 to 1750 mc./sec. was better than 9 db over isotropic.

The performance of the above-described antenna clearly indicates that the antennas of the invention provide excellent rotatable beams for use particularly in the HF to UHF spectrum. In comparison to the well-known parasitic types of antennas which bear some resemblance to those of the invention, such as the Yagi array, the antennas of the invention provide a much wider bandwidth with essentially comparable directivity. Advantageously, however, the antennas of the invention need no adjusting for their performance over a wide bandwidth, compared to the parasitic types which must be adjusted by cut-and-try procedures for each frequency. Further experimental work with other antennas similar to that described above has indicated that the preferred values for the parameters which define the antennas of the invention include a range of values for angle α between about 20° and 100°, with τ having a value between about 0.8 and about 0.95. When these parameters have values within the preferred ranges the antennas were

3

found to have essentially frequen
formance over any desired bandwi
lower limits of the bandwidths may
by fixing the lengths of the longest d
dipole, respectively. It has been
mentally that the longest dipole el
proximately 0.47 wavelength long a
the shortest element should be ab
long at the upper limit. Moreover,
a suitable front-to-back ratio at the
there should be at least 3 dipoles in
ably about 10 to 30 dipoles.

The foregoing detailed descriptio
clearness of understanding only, and
itations should be understood therefr
will be obvious to those skilled in th

What is claimed is:

1. A broadband unidirectional an
array of substantially coplanar and
progressively increasing length and
side relationship, the ratio of the len
jacent dipoles being given by the for

$$\frac{L_{(n+1)}}{L_n}=\tau$$

where L_n is the length of any interm
array, $L_{(n+1)}$ is the length of the adj
and τ is a constant having a value less
between said dipoles being given by t

$$\frac{\Delta S_{(n+1)}}{\Delta S_n}=\tau$$

where ΔS_n is the spacing between th
length L_n and the adjacent larger di
spacing between the dipole having the
adjacent smaller dipole, and τ has the
ously assigned, said dipoles being fed
mon feeder which alternates in phase
dipoles.

2. The array of claim 1 which is sy
line passing through the midpoint of
array.

3. A broadband unidirectional ante
array of a plurality of substantially co
dipoles of progressively increasing len
relationship, the ends of said dipoles fal
line forming an angle α at its vertex
lengths of any pair of adjacent dipol
the formula

$$\frac{L_{(n+1)}}{L_n}=\tau$$

where L_n is the length of the longer d
$L_{(n+1)}$ is the length of the shorter dipo
stant having a value less than 1, the dip
being fed in series by a common feede
180° in phase between successive dipole

4. The antenna of claim 3 in which
value between about 20° and 100° an
has a value between about 0.8 and 0.95.

5. The antenna of claim 3 in which
balanced line which twists 180° betwee
to successive dipoles.

6. A broadband unidirectional anten
balanced feeder line consisting of tw
straight and parallel conductors, a plu
each consisting of two dipole element
elements is connected to one of said
other element being connected directly
to the other of said conductors, the
dipole extending in opposite directions
the plane determined by said conduc
dipole elements on each of said conduc
opposite directions, the ratio of the le

3,210,767

Patented Oct. 5, 1965

2

the adjacent smaller dipole, and τ eviously given.

rn of the antennas of the invention, al relationship among the several e, is unidirectional in the negative ing to the left from the narrow end GURE 1.

f an actual antenna made in ac- ntion is shown in FIGURE 2. In nced line consists of two closely- ctrically conducting small diameter hich are attached the dipoles, each wo individual dipole elements, e.g., 1n, etc. It will be noted that each making up one dipole is connected said conductors 17 and 18, in a r to the plane determined by said Moreover, considering either one nd 18, consecutive dipole elements eof extend in opposite directions. his construction has the effect of of the connection between succes- ated schematically in FIGURE 1. of FIGURE 2 are not precisely co- refrom by the distance between the in practice this distance is very small elements are substantially coplanar f the invention are maintained. The E 2 may be conveniently fed by able 22 positioned within conductor luctor 23 thereof extending to and nection with conductor 17 as shown. the invention, an antenna of the JRE 2 was constructed using 0.125 g for the balanced line and 0.050 or the elements. The elements were line with soft solder, and the array ure coaxial cable inserted through ne conductors. The antenna was ters τ=0.95 and α=20°. The an- 5 dipoles, with the longest dipole ng, while the shortest element was , or 1¼". The array was 7½"

patterns for the above-described e and the H plane are shown in espectively. These patterns were tially constant over the band of nc./sec. The minimum front-to- nd was 17 db and the directivity bout 1130 to 1750 mc./sec. was tropic.

of the above-described antenna he antennas of the invention pro- beams for use particularly in the In comparison to the well-known nas which bear some resemblance on, such as the Yagi array, the on provide a much wider band- comparable directivity. Advan- antennas of the invention need performance over a wide band- parasitic types which must be procedures for each frequency. ork with other antennas similar has indicated that the preferred ers which define the antennas of range of values for angle α be- 0°, with τ having a value between 95. When these parameters have erred ranges the antennas were

3,210,767

3

found to have essentially frequency independent performance over any desired bandwidth. The upper and lower limits of the bandwidths may be adjusted as desired by fixing the lengths of the longest dipole and the shortest dipole, respectively. It has been determined experimentally that the longest dipole element should be approximately 0.47 wavelength long at the lower limit and the shortest element should be about 0.38 wavelength long at the upper limit. Moreover, in order to provide a suitable front-to-back ratio at the low frequency limit, there should be at least 3 dipoles in the array and preferably about 10 to 30 dipoles.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

What is claimed is:

1. A broadband unidirectional antenna comprising an array of substantially coplanar and parallel dipoles of progressively increasing length and spacing in side-by-side relationship, the ratio of the lengths of any two adjacent dipoles being given by the formula

$$\frac{L_{(n+1)}}{L_n}=\tau$$

where L_n is the length of any intermediate dipole in the array, $L_{(n+1)}$ is the length of the adjacent smaller dipole and τ is a constant having a value less than 1, the spacing between said dipoles being given by the formula

$$\frac{\Delta S_{(n+1)}}{\Delta S_n}=\tau$$

where ΔS_n is the spacing between the dipole having the length L_n and the adjacent larger dipole, $\Delta S_{(n+1)}$ is the spacing between the dipole having the length L_n and the adjacent smaller dipole, and τ has the significance previously assigned, said dipoles being fed in series by a common feeder which alternates in phase between successive dipoles.

2. The array of claim 1 which is symmetrical about a line passing through the midpoint of each dipole in the array.

3. A broadband unidirectional antenna comprising an array of a plurality of substantially coplanar and parallel dipoles of progressively increasing length in side-by-side relationship, the ends of said dipoles falling on a V-shaped line forming an angle α at its vertex, the ratio of the lengths of any pair of adjacent dipoles being given by the formula

$$\frac{L_{(n+1)}}{L_n}=\tau$$

where L_n is the length of the longer dipole of the pair, $L_{(n+1)}$ is the length of the shorter dipole, and τ is a constant having a value less than 1, the dipoles in said array being fed in series by a common feeder which alternates 180° in phase between successive dipoles.

4. The antenna of claim 3 in which the angle α has a value between about 20° and 100° and the constant τ has a value between about 0.8 and 0.95.

5. The antenna of claim 3 in which said feeder is a balanced line which twists 180° between the connections to successive dipoles.

6. A broadband unidirectional antenna comprising a balanced feeder line consisting of two closely spaced, straight and parallel conductors, a plurality of dipoles each consisting of two dipole elements, one of which elements is connected to one of said conductors, the other element being connected directly opposite the first to the other of said conductors, the elements of any dipole extending in opposite directions perpendicular to the plane determined by said conductors, consecutive dipole elements on each of said conductors extending in opposite directions, the ratio of the lengths of the elements in any two adjacent dipoles being given by the formula

4

$$\frac{l_{(n+1)}}{l_n}=\tau$$

where l_n is the length of an element of any dipole in the antenna, $l_{(n+1)}$ is the length of an element in the adjacent smaller dipole and τ is a constant having a value less than 1, the spacing between said dipoles being given by the formula

$$\frac{\Delta S_{(n+1)}}{\Delta S_n}=\tau$$

where ΔS_n is the spacing between the dipole having the element length l_n and the adjacent larger dipole, $\Delta S_{(n+1)}$ is the spacing between the dipole having the element length l_n and the adjacent smaller dipole, and τ has the significance previously assigned.

7. The antenna of claim 6 wherein τ has a value of about 0.8 to 0.95.

8. The antenna of claim 6 wherein said feeder line conductors are tubular.

9. An aerial system including at least one set of parallel dipoles spaced along and substantially perpendicular to the longitudinal axis of a two-conductor balanced feeder to which the halves of the dipoles are connected at their inner ends, said dipoles being of different electrical lengths increasing substantially logarithmically from the connected end of the feeder to the other end and the dipole feeder connections being crossed over one another between adjacent dipoles, the spacings between which also increase substantially logarithmically from said connected end to the other end.

10. An antenna system for wide-band use comprising a plurality of substantially parallel conducting dipole elements arranged in substantially collinear pairs, the opposite dipole elements of each pair constituting dipole halves, a two-conductor balanced feeder having one conductor connected to each of said elements at substantially the inner end thereof, each of said dipole halves in a pair being connected to a different feeder conductor, adjacent dipole elements being reversely connected to different conductors of the feeder, said dipole elements being selectively spaced along and substantially perpendicular to said feeder, the elements of each pair being of substantially equal length, adjacent dipole elements of different pairs differing in length with respect to each other by a substantially constant scale factor, the selective spacings between adjacent dipoles generally decreasing from one end of the feeder to the other with the greatest spacing being between the longest dipoles, and means to connect the feeder to an external circuit at substantially the location of the smallest of the dipole elements.

11. An antenna system for wide-band use comprising a plurality of substantially parallel conducting dipole elements arranged in substantially collinear pairs, the opposite dipole elements of each pair constituting dipole halves, a two-conductor balanced feeder having one conductor connected to each of said elements at substantially the inner end thereof, each of said dipole halves in a pair being connected to a different feeder conductor, adjacent dipole elements being reversely connected to different conductors of the feeder, said dipole elements being selectively spaced along and substantially perpendicular to said feeder, the elements of each pair being of substantially equal length, adjacent dipole elements of different pairs differing in length with respect to each other by a substantially constant scale factor, the selective spacings between the dipoles along the feeder differing from each other also by a substantially constant scale factor, the greatest spacing being between the longest dipoles, and means to connect the feeder to an external circuit at substantially the location of the smallest of the dipoles.

12. The aerial system of claim 11 in which said scale

3,210,767

5

factors have values within the range from about 0.8 to about 0.95.

13. An antenna system for wide-band use comprising an array of at least three linear substantially parallel conducting dipoles, each dipole being composed of two opposite substantially collinear conducting elements, a two-conductor balanced feeder having one conductor connected to each of said elements at substantially the inner end thereof, adjacent parallel dipole elements being reversely connected to a different conductor of the feeder, the two elements of each dipole being of substantially equal length and successive elements being of lengths which differ from one dipole to the next by a substantially constant scale factor within the range from about 0.8 to about 0.95, the dipoles being spaced from each other in a generally decreasing manner in the direction of decreasing element length, and means to connect the feeder conductors to an external circuit at substantially the location of the smallest dipole elements.

14. An antenna system for wide-band use comprising a minimum of three pairs of linear substantially parallel conducting elements arranged substantially coplanarly, each pair being substantially collinear and comprising the halves of a dipole, a two-conductor feeder connected to the inner ends of said collinear pairs of elements, adjacent parallel elements being connected to different conductors of the feeder so that the halves of the dipoles connect to different conductors of the feeder and adjacent dipoles are reversely connected, the halves of each dipole being substantially the same length, adjacent dipole elements being selectively spaced from each other along the feeder, the length of the successive dipole elements along the feeder decreasing in accordance with a substantially constant scale factor, each dipole and the feeder between it and the adjacent dipole constituting a cell, the dimension of the several cells measured from the point of connection of one dipole and the feeder to the outer end of the next smaller adjacent dipole also decreasing from one cell to the next in the direction of decreasing dipole length according to a substantially constant scale factor so that the combination of cells provides a substantially uniform wide-band response, and means to

6

connect an external circuit to the feeder elements at substantially the location of the shortest of the dipoles.

15. An antenna system for wide-band use comprising a minimum of three pairs of substantially parallel and coplanar linear conducting elements arranged in substantially collinear pairs, each pair of elements comprising the halves of a dipole, a two-conductor feeder, one conductor of which is connected to each of said elements substantially at the inner end thereof, adjacent parallel elements being connected to different conductors of the feeder so that the halves of the dipoles connect to different conductors of the feeder and adjacent dipoles are reversely connected, the halves of each dipole being substantially the same length, adjacent dipole elements being selectively spaced from each other along the feeder, the lengths of the elements decreasing from one end of the feeder to the other substantially in accordance with a substantially constant scale factor within the range from about 0.8 to 0.95, each dipole and the feeder between it and the adjacent dipole constituting a cell, the cell dimension from the inner end of one dipole to the outer end of the next smaller adjacent dipole also generally decreasing from one cell to the next in the direction from the longer to the shorter dipoles so that the combination of cells provides a substantially uniform wide-band response, and means to connect an external circuit to the feeder elements at substantially the location of the shortest of the dipoles.

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2,507,225	5/50	Scheldorf	343—814 X

FOREIGN PATENTS

1,023,498	1/58	Germany.
408,473	4/34	Great Britain.

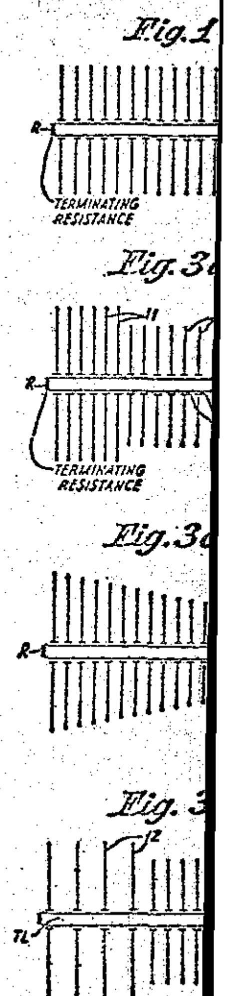
HERMAN KARL SAALBACH, *Primary Examiner*.

GEORGE N. WESTBY, ELI LIEBERMAN, *Examiners*.

UNIVERSITY (

APPENDIX B

March 5, 1940.



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...cuit to the feeder elements at sub-
...of the shortest of the dipoles.
...tem for wide-band use comprising
...pairs of substantially parallel and
...cting elements arranged in substan-
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...ect an external circuit to the feeder
...tially the location of the shortest of

...ces Cited by the Examiner

...ED STATES PATENTS

... Katzin ---------------- 343—811
... Scheldorf ---------- 343—814 X

...OREIGN PATENTS

... Germany.
... Great Britain.

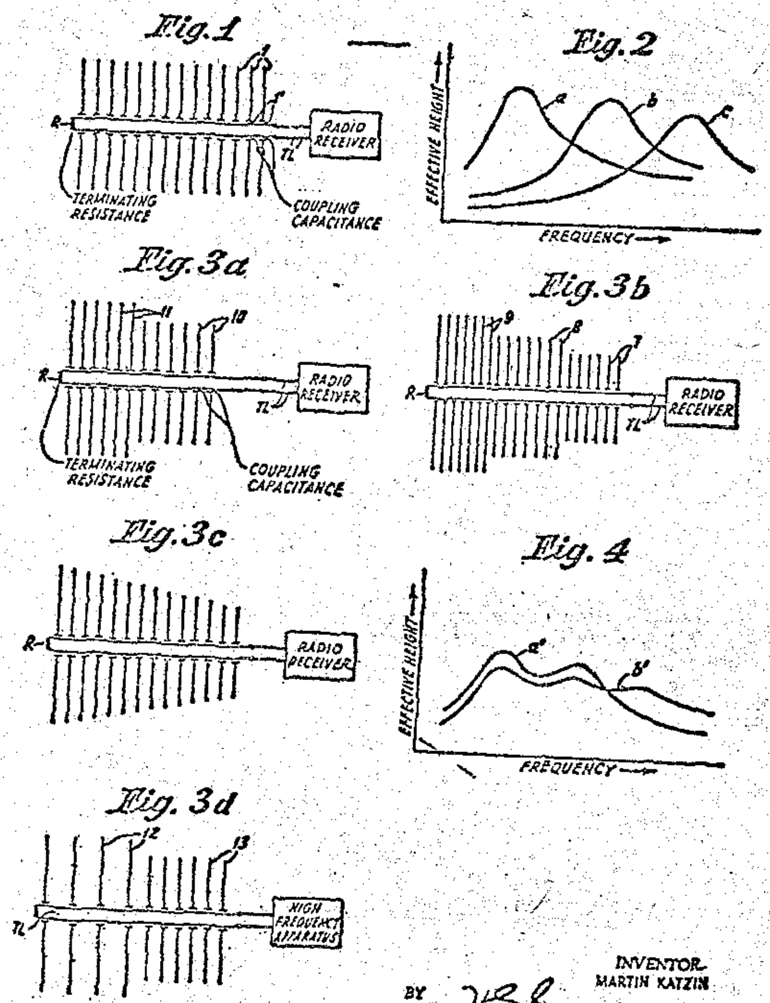
...SAALBACH, *Primary Examiner.*
...TBY, ELI LIEBERMAN, *Examiners.*

APPENDIX B

March 5, 1940. M. KATZIN 2,192,532

DIRECTIVE ANTENNA

Filed Feb. 5, 1936



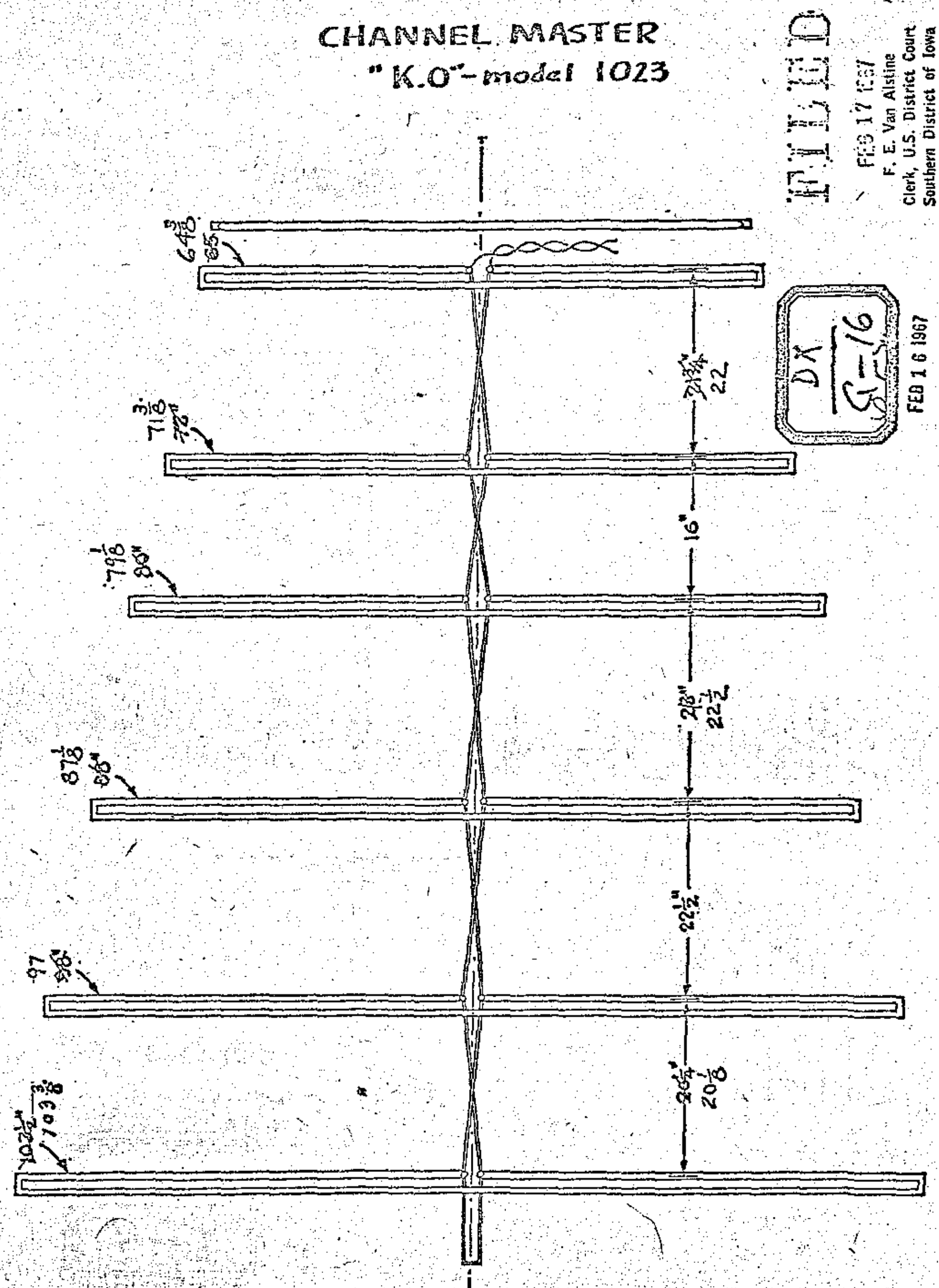
INVENTOR
MARTIN KATZIN

BY H. B. Grover

ATTORNEY.

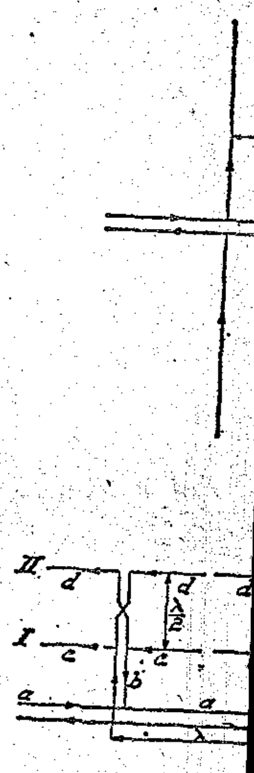
DX
E-4

APPENDIX C

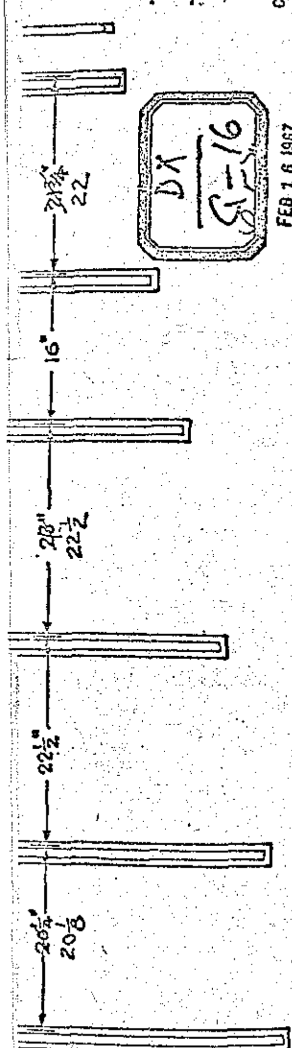


APPENDIX D

June 26, 1934.



APPENDIX D



June 26, 1934. N. KOOMANS 1,964,189

DIRECTIVE ANTENNA

Filed Sept. 11, 1928

Fig. 1.

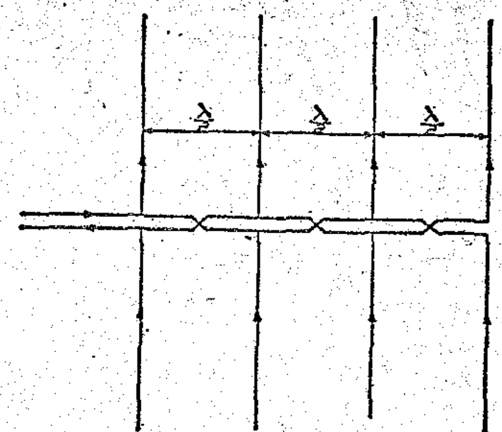
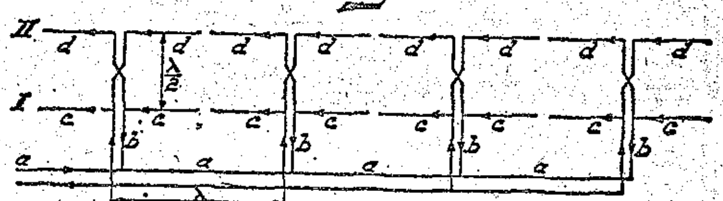


Fig. 2.



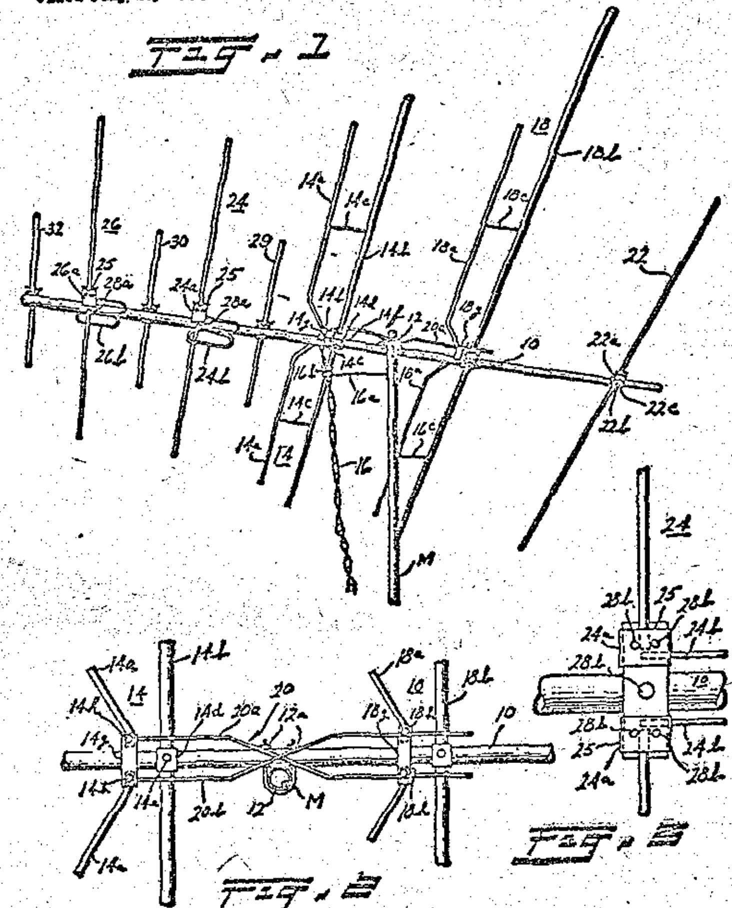
Inventor:
N. Koomans
By Langner, Parry, Card & Langner
Attys

APPENDIX E

Jan. 18, 1955 J. R. WINEGARD 2,700,105

T. V. ANTENNA ARRAY

Filed July 26, 1954 2 Sheets-Sheet 1

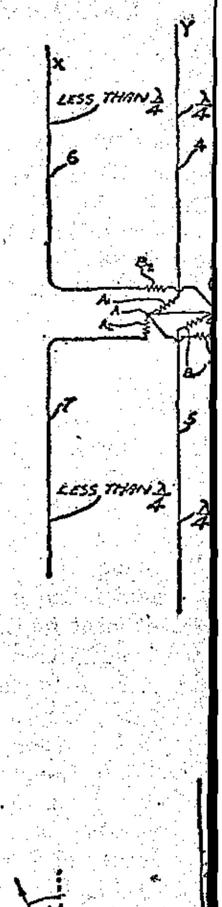


INVENTOR.
John R. Winegard
BY:
Baird, Freeman & Molinare
Att'ys.

DX
D-1

APPENDIX F

Jan. 18, 1938.

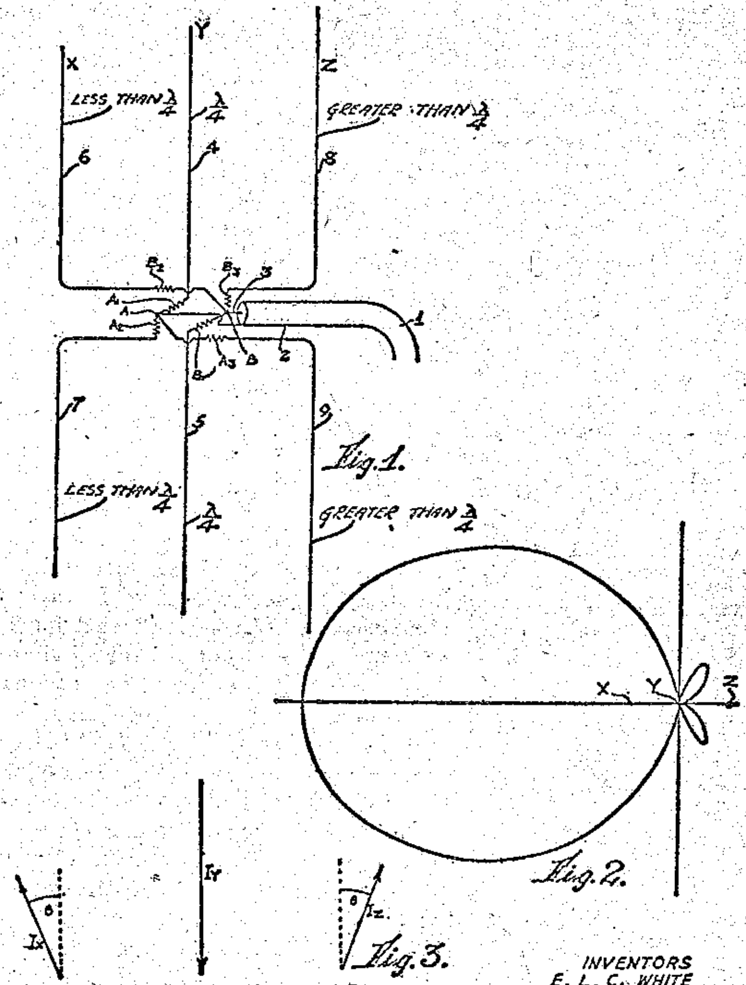


APPENDIX F

Jan. 18, 1938. E. L. C. WHITE ET AL 2,105,569

DIRECTIONAL WIRELESS AERIAL SYSTEM

Filed April 6, 1936



INVENTORS
E. L. C. WHITE
W. S. PERCIVAL
BY H. S. Grover
ATTORNEY

Litigation

June 27, 1967

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

* I enclose a copy of the decision in the Winegard suit. I have read it very hurriedly. It is my initial feeling that the judge did a good job of analyzing the prior art and of applying it to the claims.

Unfortunately, he did not even discuss the question of Quarterly Report No. 2 and its effect as a statutory bar.

Very truly yours,

Richard S. Phillips

RSP:iag

* Enclosure

cc: Mr. I. S. Blonder (*)

June 27, 1967

Mr. Keith J. Kulie
Burmeister & Kulie
135 South LaSalle Street
Chicago, Illinois 60603

RE: UIF v. Winegard

Dear Keith:

Thanks very much for the copy of the decision. I think this may be a hard one to overturn on appeal. You must have done a great job presenting the antenna theory. The judge seems to have a good understanding of it.

Very truly yours,

Richard S. Phillips

RSP:iag

Litigation
UIP v BT v JPD

August 3, 1967

Mr. Keith J. Kulie
Burmeister & Kulie
135 South LaSalle Street
Chicago, Illinois 60603

Dear Keith:

Thanks for the copy of the judge's order on the motion. I think the substitute footnote is even better than the original.

Very truly yours,

Richard S. Phillips

RSP:iag

BURMEISTER & KULIE

135 SOUTH LA SALLE STREET, CHICAGO, ILLINOIS 60603

MARSHALL A. BURMEISTER
KEITH J. KULIE
DONALD B. SOUTHARD

ATTORNEYS AT LAW - FRANKLIN 2-1344, CENTRAL 6-3351

July 31, 1967

Richard Phillips, Esq.
Hofgren, Wegner, Allen, Stellman & McCord
20 N. Wacker
Chicago, Illinois

RE: UIF -v- Winegard Company
Our File: 45-34

Dear Dick:

Enclosed is a copy of the July 18 order of Judge Stephenson in the above case.

You will note that the order deletes the last sentence of footnote 14 as it appeared in the original decision and substitutes a new last sentence.

The Foundation filed a motion under 52(b) requesting that the Court amend footnote 14 to reflect that the DuHamel article was indeed before the examiner at the time this application was in the Patent Office. They stated that the finding in fn. 14 was "clearly erroneous" as phrased.

We opposed their motion on the ground that the note was precisely accurate for the point it made with respect to claims 1 - 8.

The Court obviously intended to state exactly what we read in the footnote and made that intention clear in its amendment of July 18.

A Notice of Appeal was filed on July 27. We propose to keep this moving along as quickly as possible.

Sincerely yours,

Keith J. Kulie

k

enc.

IN THE UNITED STATES DISTRICT COURT

FOR THE SOUTHERN DISTRICT OF IOWA

DAVENPORT DIVISION

FILED

JUL 18 1967

F. E. VAN ALSTINE
CLERK, U. S. DISTRICT COURT
SOUTHERN DISTRICT OF IOWA

UNIVERSITY OF ILLINOIS FOUNDATION,
Plaintiff,

vs.

WINEGARD COMPANY,
Defendant.

Civil No. 3-695-D

O R D E R

This matter is now before the Court on the plaintiff's motion pursuant to Fed. R. Civ. P. 52(b) to amend the Court's finding of fact. More specifically, the plaintiff moves the Court to reconsider and amend footnote 14 of the opinion which was filed June 23, 1967.

After having considered the briefs of counsel and after having examined PX-68, referred to in plaintiff's motion, it is the view of the Court that the said footnote 14 would more accurately express the meaning intended by the Court, and more precisely conform to the evidence if it were amended as set out below.

IT IS ORDERED that footnote 14 of the memorandum opinion filed herein on June 23, 1967, be and the same is hereby amended, by deleting the last sentence thereof, and substituting in its place the following sentences, to wit:

> However, there is nothing in the file wrapper to indicate that, in ruling on the patentability of the Isbell patent, the patent examiners considered the published

work of DuHamel and Ore, the formula set out therein, or the log periodic theory of antenna design all of which was a part of the prior art at the time of the application. Reference was made thereto in the interference proceedings as indicated in PX-68.

Dated this 18th day of July, 1967.

/s/ Roy L. Stephenson
CHIEF JUDGE

Litigation

October 31, 1967

Mr. Robert H. Rines
Rines and Rines
No. Ten Post Office Square
Boston, Massachusetts 02109

RE: UIF v. BT v. JFD

Dear Bob:

* I enclose a copy of the Foundation's brief on appeal in the Winegard suit.

Very truly yours,

Richard S. Phillips

RSP:iag

* Enclosure

BURMEISTER, KULIE, SOUTHARD & GODULA

135 SOUTH LA SALLE STREET, CHICAGO, ILLINOIS 60603

MARSHALL A. BURMEISTER
KEITH J. KULIE
DONALD B. SOUTHARD
EDMUND A. GODULA

ATTORNEYS AT LAW-FRANKLIN 2-1344, CENTRAL 6-3351

October 30, 1967

Richard Phillips, Esq.
Hofgren, Wegner, Allen, Stellman & McCord
20 North Wacker Drive
Chicago, Illinois

RE: UIF -v- Winegard Company
Brief on Appeal (UIF)
Our File: 45-34

Dear Dick:

Enclosed is a copy of the University brief on appeal. In reviewing the material quickly it appears to involve substantially the same arguments presented to the District Court.

Sincerely yours,

Keith J. Kulie

k

enc.

RECEIVED
OCT 3X 1967
HOFGREN, WEGNER, ALLEN,
STELLMAN & McCORD

In the

United States Court of Appeals

For the Eighth Circuit

No. 19000
Civil

UNIVERSITY OF ILLINOIS FOUNDATION,
Appellant,

vs.

WINEGARD COMPANY,
Appellee.

APPEAL FROM THE UNITED STATES DISTRICT COURT FOR THE SOUTHERN DISTRICT OF IOWA, DAVENPORT DIVISION.

APPELLANT'S BRIEF.

Charles J. Merriam,
William A. Marshall,
Basil P. Mann,
30 West Monroe Street,
Chicago, Illinois 60603,
Area Code 312-346-5750,
Attorneys for Plaintiff.

Of Counsel:
Merriam, Marshall, Shapiro & Klose,
30 West Monroe Street,
Chicago, Illinois 60603,
Cook, Blair, Balluff & Nagle,
409 Putnam Building,
Davenport, Iowa 52801.

THE GUNTHORP-WARREN PRINTING COMPANY, CHICAGO

INDEX.

AUTHORITIES CITED.

In the

United States Court of Appeals

For the Eighth Circuit

No. 19,000.
Civil.

UNIVERSITY OF ILLINOIS FOUNDATION,
Appellant,

vs.

WINEGARD COMPANY,
Appellee.

APPEAL FROM THE UNITED STATES DISTRICT COURT FOR THE SOUTHERN DISTRICT OF IOWA, DAVENPORT DIVISION.

APPELLANT'S BRIEF.

I. STATEMENT OF THE FACTS.

This action was brought by plaintiff, University of Illinois Foundation, against defendant, Winegard Company, for infringement of Claims 1-5 and 9-15 of Isbell United States Patent 3,210,767, covering a novel type of broadband radio and television antenna.

A. Background.

In the following discussion we will endeavor to point out in language which we hope will be intelligible, even if this Court is not electrically trained, the necessary factors involved in television reception. We hope that our approach will not be so elementary as to offend.

Television broadcasting involves the sending of information via electromagnetic waves from a broadcasting station to a mass audience consisting of the individual owners of television receivers. The television transmitter is usually located on top of a tall structure, such as a building or a tower, near the center of the population area. The television transmitter sends power in the form of radio frequency waves through the earth's atmosphere toward the television receivers in the area, usually in all directions (R. 58).*

Within any given metropolitan television broadcast service region, the atmosphere contains many complex electrical disturbances in the form of radio frequency waves of various types, including those of the television transmitters operating in the area (R. 61, 62). In order to receive a particular television transmission, the owner of a television set must use a receiving antenna to pick up the television signal and deliver it to the television set in a form that can be used (R. 58, 59). Depending on the circumstances, it is possible to use antennas having many different configurations. For example, in the case of television receivers located relatively close to the transmitter, the simple whip or "rabbit-ear" rod antenna mounted directly on the television receiver cabinet can be used (R. 65) to give satisfactory performance, at least for nearby black and white reception. This type of antenna is a simple dipole.**

---

* "R." refers to the Record, filed herewith; "PX" refers to Plaintiff's Exhibits; "DX" refers to Defendant's Exhibits.

** Generally, in this context, a simple straight dipole (*i.e.*, two poles) antenna element consists of two elongated metallic conductors (wires, rods or tubes) arranged approximately colinearly in such a manner that there is a small gap or terminal between their inner ends, at which point a transmission line is attached. The "rabbit-ear" indoor television antenna is a simple dipole having its arms at an angle rather than in a straight line.

When within an electromagnetic field, a dipole element will intercept electromagnetic waves and produce a voltage across its terminals (R. 62). This voltage is carried to the receiver by means of the transmission line. A dipole, like any other electrical conductor, will intercept radiated energy from the atmosphere to a certain extent, regardless of the wave length* of the energy being transmitted. There is, however, a special condition, known as "resonance," in which the dipole is strongly receptive, which occurs when the dipole is of a particular length in relationship to the wavelength of the radiated energy (R. 63). A familiar analogy is the manner in which a tuning fork will resonate to its own pitch, or a piano string will vibrate when its particular note is sounded by another instrument. This condition occurs primarily when the overall length of the dipole is one-half the wavelength of the radio wave. Thus, it is apparent that a dipole can be "tuned" for optimum reception of a particular radiowave frequency by adjusting the overall length of the dipole to correspond to one-half wavelength of the signal being received (R. 63), as the length of a tuning fork will affect the pitch to which it resonates.

As the distance from the broadcasting station increases, radio waves rapidly become weaker (R. 58), so that it becomes advantageous to use an antenna having a greater capability of radiated energy extraction from the atmosphere than the simple whip or "rabbit-ear" configurations.

---

* The frequency of electromagnetic radiation and the wave-length corresponding to a particular frequency are inversely related to each other (R. 63), the product of the two quantities being a constant (equal to the velocity of light, which is a form of electromagnetic radiation). Thus, if either the frequency or the wave-length is known, the other quantity can be calculated by dividing into the speed of light. As an example, the wave-length corresponding to a frequency of 100 megacycles (100 million cycles per second) is about 9.8 feet. If this frequency is doubled (to 200 megacycles) the wave-length is halved (to 4.9 feet) and so on.

Various combinations of dipole elements and of other elements having more complex configurations have been used in the past to meet this need for more "gain" at greater distances from the transmitting station. "Gain" is a measure of the relative ability of one antenna to produce a signal (*i.e.,* a radio frequency voltage) at a given location distant from the transmitting station in comparison with another antenna similarly located. Other considerations being equal, high gain is usually desirable in an antenna (R. 61), although uniformity of gain across the band is possibly even more important in a television antenna (R. 109). The patented antennas are characterized by uniform gain across the entire band of operation (R. 108).

Another one of the properties which are desirable in a television antenna stems from the fact that television signals are capable of bouncing or reflecting from many types of man-made and natural obstructions, such as tall buildings and hills or mountains. It is, therefore, possible for a given location to receive, in addition to the primary signal coming directly from the television transmitter, a second signal from a different direction which arrives as the result of reflection from an obstruction. This reflected signal also produces a picture in the television receiver, but, because of the fact that it arrives a short time later than the original signal, the second picture is slightly displaced and produces an undesirable "ghost" image (R. 59). A solution to a problem of this type is to use a unidirectional antenna capable of receiving signals from the desired direction or directions while excluding signals which arrive from other directions. The ability of a television receiver to discriminate in this manner is a measure of the antenna's "directivity" (R. 59).

When most of the television transmitters which serve a given metropolitan area are located reasonably close to one another (a situation which is usual in many metropolitan areas), it is an obvious advantage that a television antenna have a unidirectional directivity (R. 67, 68), *i.e.*, that it be capable of receiving signals only from the direction in which it is pointed while rejecting signals from the side or rear. The antennas of the patent in suit have this desirable unidirectional property (PX-31, Col. 1, lines 21-23).

Another property which is important in a television antenna, and indeed crucial for color reception, is the ability to receive signals equally well over a wide band of frequencies (R. 108, 109). The patented antennas have this property. Every user of a television set knows that television programs are received on one or more of twelve broadcasting channels known as VHF (Very High Frequency) channels 2 through 13. These channels were established shortly after World War II by the Federal Communications Commission on fixed frequency assignments which have been maintained ever since. More recently, additional UHF (Ultra High Frequency) channels 14 through 83 at higher frequency assignments were established and are coming into increasing use (R. 69-72).

The channel assignments by the Federal Communications Commission in the VHF range provided for twelve channels, numbers 2 through 13, inclusive, which occupied frequencies in the electromagnetic spectrum from 54 megacycles through 216 megacycles, arranged in two bands, channels 2 through 6 designated as the low band (54 through 88 megacycles), and channels 7-13 as the high band (174 through 216 megacycles) (R. 70, 71). These channel assignments created such problems in the antenna engineering art and presented such extreme challenges to the television receiving antenna designers (R. 73, 74, 90) that it was necessary to use compromise techniques (R. 82, 83) to provide satisfactory receiving antennas for television, since there was no available antenna design at that time which would cover such a broad range of frequencies.

It is possible, of course, to design and use an individual dipole antenna for each channel (R. 73). Such an attempted solution, however, presents a number of difficulties which have rendered this seemingly obvious answer to the problem completely unuseful in practice. In addition to greatly increased cost (R. 74), there are further difficulties resulting from the unpredictable effects of interaction among several antennas placed close together. Still another difficulty is presented by the method to be used in connecting the individual antennas to the television set. Multiple transmission lines cannot be simply connected to the input of a television receiver without special matching sections which are necessary to avoid a severe "impedance mismatch" between the antenna and the receiver with consequent deterioration of performance (R. 73-74, 77-78).

The "impedance" (R. 60, 61, 64, 68-70, 77-78) of an antenna is its apparent resistance to the passage of alternating current. The impedance is an inherent property which is determined by the antenna design and by the wave lengths being received. The other major component of the antenna system, *i.e.*, the transmission line to the receiver, also has a characteristic impedance, the value of which depends in part on its physical dimensions. In order to maximize the transmission of signal power from the antenna to the transmission line (and, therefore, from the transmission line to the receiver), the impedances of the antenna and of the transmission line should be equal (R. 78). Additionally, therefore, the antenna impedance should match as closely as possible the impedance of the transmission line, which has a value of about 300 ohms for the commonly used twin-lead line (R. 60), which is accepted as the standard of the industry (R. 77). Moreover, although the impedance of the antenna varies with frequency, it is desirable to minimize this variation as much as possible in order to maintain a close "impedance match" between the antenna and the transmission line (R. 64).

In order to avoid, insofar as possible, the problems mentioned above, it was common to use a compromise antenna for the low band of VHF channels (2 through 6) and another compromise antenna to cover the high band of VHF channels 7 through 13 (R. 82, 83).

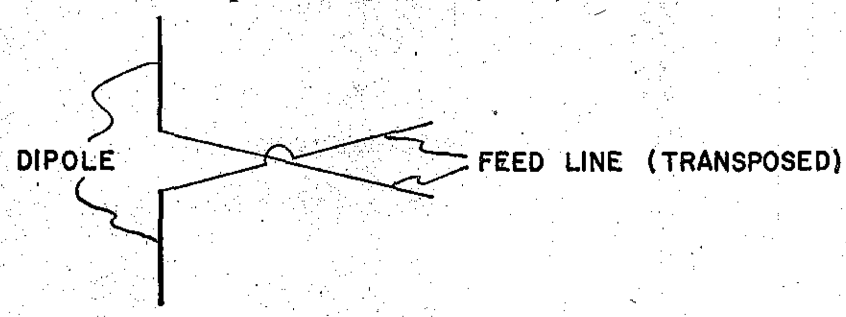
While this compromise method of operation was satisfactory for black and white television, it was not good enough for color television. The underlying difficulty which precludes the use of compromise antennas intended to receive an average frequency or one in the approximate middle of the desired band stems from the fact that each television channel is not a single, fixed frequency, but rather a band of frequencies 6 megacycles (6 million cycles) wide (R. 70). For optimum reception of the sound and picture information transmitted on a given channel, all of the frequencies within the band should be received by the antenna and supplied to the receiver in the same relative magnitude as sent by the broadcasting station. Thus, unless the television antenna has a uniform gain across the channel, it will vary the relative magnitude of the various frequencies it receives and thereby introduce distortion in the signal fed to the receiver (R. 129, 130). When all television broadcasting was black and white, the distortion caused by nonuniform reception across the band was of relatively little concern since it did not greatly affect the quality of the picture. With color television, such frequency discrimination caused by the antenna can result in deterioration of the colors in the picture (R. 108, 109, 129, 130).

B. The Patent in Suit.

Isbell patent No. 3,210,767 (PX 31), the patent in suit, discloses and claims antennas consisting of several straight, parallel dipoles arranged approximately in a plane, each dipole being connected to a feeder line consisting of two conductors which are transposed, i.e., cross over each other, between connections to adjacent dipoles.

In the Isbell antenna, the lengths of the dipoles and the spacings between adjacent dipoles vary progressively from the longest at the back to the shortest at the front, which is the feed-point of the antenna, *i.e.,* the point at which the tranmission line is connected. The lengths and spacings of the dipoles vary in accordance with a constant scale factor (τ) having a value less than one, any length or spacing being calculated by multiplying the adjacent longer length or spacing by the scale factor.

The antennas covered by the Isbell patent belong to the class of antennas known as logarithmically periodic (log-periodic) arrays (R. 91, 100), which are composed of repeating design cells* (R. 91) generally of similar shape, but of varying size. In the Isbell antenna the design cell is a straight dipole plus an adjacent section of transmission line with transposed conductors (R. 92):



* The term "design cell" is used herein to refer to a structural unit of a log-periodic antenna which is capable of receiving and transmitting electromagnetic radio energy. A simple or folded dipole and an adjacent section of transmission line are examples of such antenna design cells. Many other design cells can be conceived, including arcs of circles and other curves, trapezoidal and saw-tooth shapes, etc. (DX-A-1, p. 140). Although many different design cells are theoretically possible, only a few have been found to yield frequency independent performance in log-periodic antennas (DX-A-10b, R. 191; DX-A-1, R. 189). A particular antenna array may be composed of one or more similar or dissimilar design cells.

Antennas designed in accordance with the Isbell patent specifications have unidirectional radiation patterns and high quality performance which are, over a wide band of frequencies, essentially independent of the frequency of the electromagnetic waves being transmitted or received. The Isbell antenna has broad application in the field of radio communication. The invention has particular commercial significance because it has provided a unique solution to the problem of wide-band television reception (R. 111, 148, 149), particularly of color television signals, in that one antenna of relatively simple and economical construction could be made to cover the entire television broadcasting band, including the UHF channels, if desired, with a uniformly high gain across the entire band, thereby eliminating color deterioration problems (R. 108). In addition, the antenna requires only one transmission line to the television set, eliminating impedance matching problems and, in addition, has unidirectional directivity which can be used to eliminate ghosts and other unwanted signals (PX-31).

II. STATEMENT OF POINTS TO BE ARGUED AND OF AUTHORITIES.

1. The frequency independent antennas constituting the invention of the patent in suit, which employ dipole elements and specified scaling factors to determine dipole length, design cell dimensions, and spacing between dipoles, were not obvious to one having ordinary skill in the art at the time the invention was made. *Graham* v. *John Deere Co.*, 383 U. S. 1 (1966); *United States* v. *Adams*, 383 U. S. 39 (1966); *Great Atlantic & Pacific Tea Co.* v. *Supermarket Equip. Corp.*, 340 U. S. 147 (1950); *L & A Products, Inc.* v. *Britt Tech Corp.*, 365 F. 2d 83 (8th Cir. 1966).

2. Where findings of fact are based on documentary evidence, the reviewing court is in as good a position as the trial court to judge the evidence. Such findings are not binding on the appellate court and will be given slight weight on appeal. *American Infra-Red Radiant Co.* v. *Lambert Industries, Inc.*, 360 F. 2d 977, 988 (8th Cir. 1966); *State Farm Mut. Automobile Ins. Co.* v. *Bonacci*, 111 F. 2d 412, 415 (8th Cir. 1940); *Nasco, Inc.* v. *Vision-Wrap, Inc.*, 352 F. 2d 905, 908 (7th Cir. 1965).

3. Where an attack on the validity of a patent is based on references which were cited and rejected by the Patent Office, the presumption of validity is greatly strengthened. *Dean Rubber Mfg. Co.* v. *Killian*, 106 F. 2d 316, 318 (8th Cir. 1939); *Nasco Inc.* v. *Vision-Wrap, Inc.*, 352 F. 2d 905, 908 (7th Cir. 1965); *Otto* v. *Koppers Co.*, 246 F. 2d 789, 801 (4th Cir. 1957).

III. ARGUMENT.

There has been an unfortunate tendency in some District Courts, since the *Graham, Cook* and *Adams* cases in the Supreme Court (383 U. S. 1 et seq.; 1966), to assume that invention is dead, and to follow what Mr. Justice Jackson deplored in *Jungersen* v. *Ostby and Barton,* 335 U. S. 560, 572 (1949) as the "strong passion in this Court for striking [patents] down so that the only patent that is valid is one which this Court has not been able to get its hands on."

To paraphrase Shakespeare, who had Marc Antony say "I come to bury Caesar, not to praise him," we seek not to bury the patent system but to praise it. If the businessmen in the United States are to keep any business advantages in world trade, these can only come from the stimulus which this country has given to innovation and particularly inventive change. We are no longer the only "haves" in a world of "have nots." We no longer have better resources than all competitive countries. It can be argued that at least two countries work more aggressively and harder than we. But this country has always been creatively inclined more than any other, and only through a strong patent system can that incentive to create be maintained. It cannot be maintained by government research, because no governmental body can properly authorize research unless it seems likely to succeed—and it is from the one who tries the seemingly impossible that we get our impetus. Our industrial farsightedness must not be thwarted by improperly applied judicial hindsight.

A. THE ISBELL INVENTION WAS NON-OBVIOUS.

The Isbell invention was not obvious because:

(1) In electronics, as in chemistry, predictions cannot be depended on, contrary to the usual situation in mechanical cases.

(2) As conceded and not controverted by defendant's witnesses, the design of a log-periodic structure which will function as a frequency-independent antenna is not predictable.

(3) While the prior art showed antennas having individual portions similar to those used by Isbell, there was no basis for combining these portions and expecting the combination to function as a frequency-independent antenna.

Predictions in Electronics Are Undependable.

The lower court erred in treating Isbell's antenna as being a combination of elements with a predictable result. While the effect of combining several elements is generally predictable in mechanical cases, this is *not* true in electronics. An inventor in the mechanical field can achieve his objects predictably because mechanical elements and mechanisms when combined function in the manner expected. For this reason, in mechanical cases, a combination of old elements is patentable "only when the whole in some way exceeds the sum of its parts." *Great Atlantic & Pacific Tea Co.* v. *Supermarket Equip. Corp.*, 340 U. S. 147, 152 (1950). The Supreme Court in the *A. & P.* case, however, recognized the problem of the inventor in the electrical arts when it stated on page 152:

> "Elements may, of course, *especially in chemistry or electronics,* take on some new quality or function from being brought into concert, but this is not a usual

result of uniting elements old in mechanics." (Emphasis added.)

In the field of antenna design, specifically, there are many possible dipole arrangements using many different dipole lengths and configurations, and many transmission line systems exist for interconnecting the dipoles and transmitting (in the case of a receiving antenna) the signal received by the dipoles to the receiver where it is heard or seen. There were no guideposts available to an antenna designer to lead him to Isbell's design out of all of the permutations and combinations which can be made with the individual antenna elements known to the art.

The Design of a Frequency Independent Log-Periodic Antenna Is Non-Obvious.

The error of the lower Court in holding that the Isbell invention was obvious in view of the prior art which it cited is further indicated by the statements in the art itself which show that the design of a specific log-periodic antenna having frequency independent properties was non-obvious, even though the general method for designing log-periodic antennas was known.

The relevant time with respect to which the question of obviousness is to be considered is the time of the invention, and courts must be wary to avoid applying hindsight in the light of subsequent knowledge of the inventor's disclosure, *Graham* v. *John Deere Co.*, 383 U. S. 1, 36 (1966). The record is replete with uncontradicted evidence showing that both before and after Isbell's invention, and even today (R. 107), the design of a log-periodic antenna which will have frequency-independent properties was and is unpredictable. Much of this evidence was in fact introduced by defendant (R. 189, 191) and corroborated by its expert witness (R. 143).

In this connection, the distinction between a log-periodic structure and a log-periodic *frequency-independent* antenna should be noted. Any structure composed of repeating cells whose dimensions are related by a constant scale factor can be said to be log-periodic in form, but would not necessarily have frequency-independent characteristics when used as an antenna. In fact, although many such log-periodic structures have been designed and built, only a very few functioned as frequency-independent antennas, and it could not be predicted which of these structures would make satisfactory antennas.

In the same article (DX-A-1) by DuHamel and Ore upon which the trial court relied for showing that the method for designing log-periodic antennas was known, the authors conclude (R. 189):

> "Many types of logarithmically periodic antenna structures have been built and tested. Most of those which gave essentially frequency independent operation have been reported here but there were many structures for which the pattern and/or impedance were quite frequency sensitive. *Unfortunately, no theory has been established which even predicts the types of structures which will give frequency independent operation.*" (Emphasis added.)

Similarly, Jasik's Antenna Engineering Handbook (DX-A-10b), which was written after Isbell's invention, states on page 18-13 (R. 191):

> "It should be pointed out that many types of log-periodic structures are not broad-band because of either extreme variation over a period or severe end-effect which destroys the periodicity of the electrical characteristics. Only the successful structures are described herein. *Unfortunately, it is not possible to determine a priori the frequency-independent types of log-periodic antennas.*" (Emphasis added.)

Even defendant's expert witness, Dr. Yang, agreed with Jasik that it is impossible to predict which log-periodic structures will make frequency-independent antennas (R. 143).

The unpredictable nature of log-periodic frequency-independent antenna design is also borne out by experience at the University of Illinois Antenna Laboratory. As Professor Mayes testified (R. 103, 104), only three or four frequency-independent log-periodic antennas were developed prior to 1960, although many attempts were made, and in spite of the fact that the constant proportional relationship among the cells of log-periodic antennas was known, the principal difficulties being those referred to in DX-A-10(b), *i.e.,* severe end-effects and non-uniform performance over a period of operation (R. 106, 107).

In this connection, it is important to keep in mind that the use of a proportional repeating cell does not automatically result in an antenna having a wide-band response. The problem is to select a particular cell design, out of the myriad of possible designs, which provides essentially uniform performance over a band of frequencies (R. 106), and for this selection there are no guidelines (R. 107). As Professor Mayes further testified (R. 107), even today, when the understanding of log-periodic antennas is much greater than that which existed when Isbell made his invention, it is still impossible to predict whether any given log-periodic structure will function as a frequency-independent log-periodic antenna.

There Was No Basis for Combining Portions of Prior Art Antennas to Arrive at Isbell's Invention.

While antennas can be found in the prior art with pieces or portions similar to parts of Isbell's antenna, these pieces cannot be separated from their environment and predictably assembled into Isbell's invention any more than an automobile carburetor can be joined with a jet engine and a charcoal burner to make a successful spaceship. Each element must be judged in its own environment and cannot be separated from it. The fact that such isolated elements are known in different combinations does not alone defeat patentability. *United States* v. *Adams,* 383 U. S. 39, 51-52 (1966); *L. & A. Products, Inc.* v. *Britt Tech Corp.,* 365 F. 2d 83 (8th Cir. 1966).

Contrary to the Supreme Court's recognition of the unpredictable nature of electronics, corroborated in this case with respect to the subject matter of Isbell's invention, the lower Court used the standard applicable especially to mechanical patents and erroneously concluded (R. 25) that:

> "... the Isbell antenna is a combination of elements, all known in the prior art and also that these known elements were combined in the Isbell antenna in a manner dictated by a theory also known in the prior art."

The Court further concluded (R. 25) that:

> "Those skilled in the art at the time of the Isbell application knew (1) the log periodic method of designing frequency independent antennas, (2) that antenna arrays consisting of straight dipoles with progressively varied lengths and spacings exhibit greater broad band characteristics than those consisting of dipoles of equal length and spacing and, (3) that a dipole array type antenna having elements spaced less than ½ wave length apart could be made unidirectional in radiation pattern by transposing the feeder line between elements and feeding the array at the end of the smallest element.
>
> "It is the opinion of the Court that it would have been obvious to one ordinarily skilled in the art and wishing to design a frequency independent unidirectional antenna to combine these three old elements, all suggested by the prior art references [identified above]."

In reviewing the lower Court's erroneous reasoning, it *must* be appreciated by this Court that the Isbell invention is not a combination of old elements, each of which has a predictable function or result. It is also significant to note that *contrary to the lower Court's assertion, there was, and is, no "log-periodic method of designing frequency independent antennas."* As previously explained, there is a method for designing log-periodic structures, but it is unpredictable whether any given log-periodic structure will have frequency-independent properties as an antenna.

None of the allegedly old elements is shown by itself in the cited references. Instead, these elements are combined in antenna structures in which all of the elements cooperatively function to achieve a desired result. One cannot logically dissect an antenna design and assume that a selected element alone is responsible for any particular aspect of the overall result. The situation is not the same as in a mechanical combination, wherein one of the parts, *e.g.*, a prime mover, such as an electric motor, can be removed from a first combination and placed in a second mechanical combination where it also will predictably function in the same way.

The lower Court's finding of obviousness was erroneously made on the same basis as one would proceed in 1967 to travel from St. Louis, Missouri to Portland, Oregon. Well-defined and well-mapped routes, permitting travel by air or land, could be used by today's traveler to reach his destination in a matter of hours.

Instead, the Court should have approached the issue of obviousness from the viewpoint of Lewis and Clark, who in 1804 desired to reach the Pacific Ocean by crossing the continent north of Mexico. While they knew their destination, the guideposts that they had to help them achieve their goal were scant or non-existent. It was only after extensive exploration that Lewis and Clark reached their goal after traveling for about one year.

It was in this latter situation that Isbell found himself in attempting to invent, using simple dipole elements, a log-periodic antenna having a response that is essentially independent of frequency over wide band widths.

The State of the Art Prior to Isbell.

Isbell's contribution can best be appreciated by considering the state of the art relating to broad-band antennas prior to Isbell's work.

As late as 1953, an antenna having a bandwidth of 2:1 (*i.e.*, the ratio of the highest to the lowest frequency of acceptable operation) was considered broad-band (R. 114-116). Because of a need for antennas with wider bandwidths, a research project for the development of such antennas was given in 1954 by the U. S. Air Force to the University of Illinois Antenna Laboratory (R. 115). While working on this project, Professor Rumsey developed in 1955 (R. 99, 117) a class of antennas (the equiangular or logarithmic spiral, Fig. 1; R. 196, DX-A-12) having broad-band capabilities, and in late 1956 or 1957, Dr. DuHamel, also of the University, invented a new class of antennas, which he termed "log-periodic" (R. 99-102, 103, 117), composed of repeating cells of similar shape but varying size, as previously discussed, and having the appearance of a "bow-tie" (R. 100, 101) with serrated or toothed edges (Fig. 2).

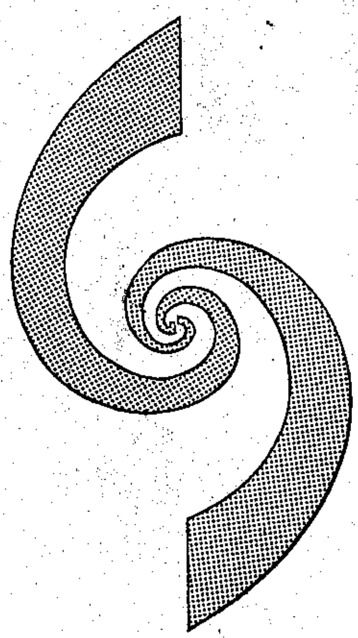


FIG. 1 EQUIANGULAR SPIRAL ANTENNA (PLANAR)

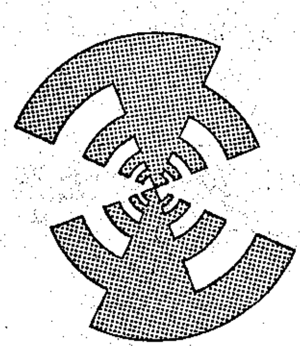


FIG. 2 "BOW-TIE" LOG-PERIODIC ANTENNA (PLANAR)

Both Rumsey's spiral antennas and the early log-periodics developed by DuHamel suffered from certain practical disadvantages. They were planar sheet metal structures and large and expensive if designed to cover the television frequencies. In addition, these antennas had bidirectional directivity as opposed to the unidirectional pattern which is desired for most applications (R. 99-100). It is interesting to observe that knowledge of the "scaling factor" which the lower Court considers as the *significant* disclosure in the DuHamel-Ore publication did not permit DuHamel and Ore to achieve a unidirectional radiation pattern with the planar "bow-tie" type of structures (R. 100).

The final step taken by Isbell in inventing the frequency-independent unidirectional antenna using dipoles in a planar arrangement as described and claimed in the patent in suit was not taught or suggested by the DuHamel and Ore publication alone or as supplemented by the prior art teachings relied upon by the Court. Isbell was the first to invent a log-periodic type of antenna which had such desired electrical characteristics and structural design attributes that made it especially adaptable as a television antenna (R. 148-149, 108). It did not have the bulk that was significant in the sheet metal configurations of Rumsey and DuHamel (R. 157). It was the first substantially *planar* log-periodic array that had unidirectional characteristics. All in all, it provided an antenna design which constituted the best practical solution to the problem of wide-band radio and television reception (R. 117-119, 148-149).

B. THE PRIOR ART DOES NOT TEACH OR SUGGEST ISBELL'S INVENTION.

In order to decide the present issue, it will be sufficient for this Court to recognize that the electrical characteristics of an antenna are not achieved by the independent action of each of the elements in the assembly, but rather by the cooperative effect of all of the elements interacting with each other. Accordingly, the restatement by the lower Court of what those skilled in the art knew at the time of the Isbell invention has to be limited to the specific antenna structures to which these specified bits of knowledge relate.

It is further important in reconsidering the prior art to note that three (*i.e.,* DuHamel-Ore, Katzin and K. O. antenna) of the principal references on which the Court relied were cited and considered by the Patent Office during the prosecution, and the other two references cited by the Court are cumulative with respect to the use of transposed feeder lines. Aside from this, these latter references add nothing pertinent or relevant to the principal references.

The prior art patent references relied upon by the Court have so little bearing on the Isbell invention that under normal circumstances they could be dismissed very briefly. Because of the trial Court's misunderstanding of their effect, however, additional consideration will have to be given them.

Katzin Patent 2,192,532.

Katzin patent 2,192,532 (R. 215) was relied upon as a teaching (R. 25)

> "that antenna arrays consisting of straight dipoles with progressively varied lengths and spacings exhibit greater broad band characteristics than those consisting of equal length and spacing".

It is submitted that the lower Court's observation is merely a truism, evident from the known phenomenon of resonance in dipoles, which can be tuned to respond strongly to certain frequencies by adjusting the length. Obviously, if an array contains dipoles of different lengths, it has a *potential* frequency coverage greater than that of an array in which the dipoles are all the same length. What is lacking, however, in the Court's observation is a teaching of how the dipoles should be arranged and interconnected so as to work together cooperatively rather than in opposition and thereby to achieve the desired result.

The Katzin patent teaches a method of joining the dipoles, using a straight (*i.e.,* not crossed-over) feeder line and loose (*e.g.,* capacitive) coupling between the feeder and the dipoles (R. 153-155). Katzin's straight feeder and loose coupling should be distinguished from Isbell's crossed-over feeder and direct coupling to the dipoles.

Katzin's antenna and Isbell's antenna involve fundamentally different modes of operation, as shown by the fact that Katzin's antenna is "end-fired" while Isbell's is "back-fired." (R. 150.)* Katzin's end-fired array is physically oriented, with respect to a transmitting station, by pointing the end opposite the receiver (*i.e.,* the large end) toward the transmitter (DX-E-4, p. 1, col. 1, lines 50-52), while with Isbell's, the small end, to which the receiver is attached, is directed toward the transmitter, as shown in Fig. 3.

* An "end-fire" antenna is one in which the radiated field travels in the same direction as that in which energy supplied thereto travels in the antenna's feeder line, considering the antenna as a transmitting antenna. In a "back-fire" antenna, the radiated field travels in a direction opposite to that in which the energy enters the antenna. In both "end-fire" and "back-fire" antennas the field travels in the plane of the antenna elements (but in opposite directions), while in a "broadside" antenna, the radiated field is perpendicular to the plane of the elements. The above relationships between the direction of the field and the direction of energy travel in the antenna's feed line also hold in receiving antennas, with respect to the radiated field being received and the signal created in the antenna by the intercepted field.

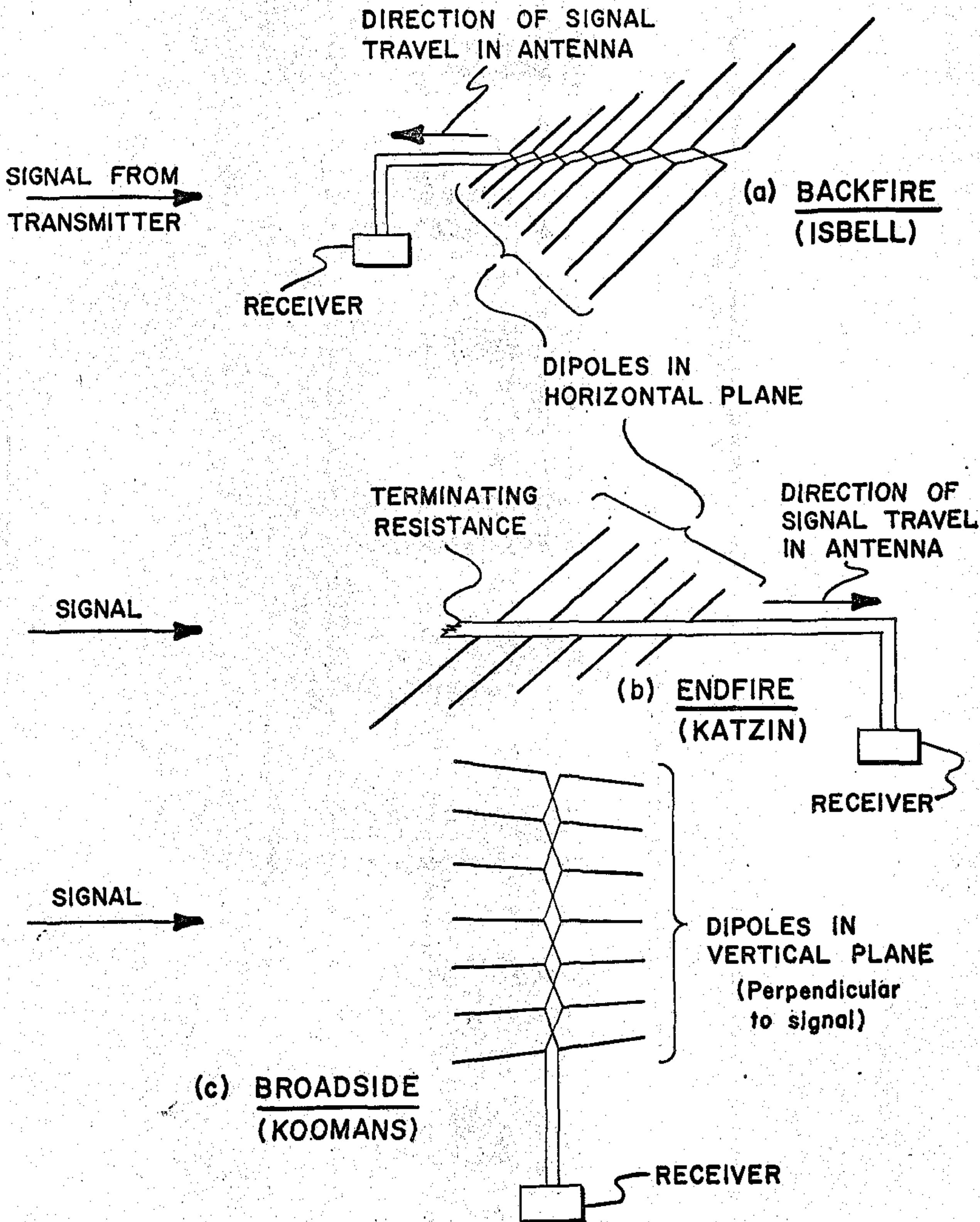


FIG. 3 EXAMPLES OF "BACKFIRE", "ENDFIRE", AND "BROADSIDE" ANTENNAS

K. O. Antenna.

The use of transposed feed lines in the K. O. antenna, as well as by Koomans in U. S. Patent 1,964,189, does not teach or suggest that the use of a transposed feed line in Katzin's array will add to its effectiveness in any way. The lower Court used as a partial basis for its opinion the fact that unidirectionality may be achieved under proper conditions by the use of transposed feed lines. If unidirectional directivity were desired by one skilled in the art, the use of transposed feeders in Katzin's antenna would have been bringing "coals to Newcastle," because the Katzin array is already unidirectional, as disclosed in the patent:

> "To make the antenna *unilateral in directivity,* the end of the TL (transmission line) nearest the desired transmitting station and farthest removed from the radio receiver is closed by a suitable terminating resistance R whose impedance is equal to the surge impedance of the line as loaded by the energy collecting doublets." (Col. 1, line 50—Col. 2, line 1.) (Emphasis added.)

The K. O. antenna (R. 197; DX-B-4), although consisting of an array of more than three *folded* dipoles (R. 81) interconnected by transposed transmission lines, is actually evidence of the invention made by Isbell. One distinction is *that the folded dipoles in the* K. O. *antenna* are not arranged in accordance with a scaling factor for dipole spacing or cell dimensions, as the lower Court found (R. 20, 21).

Another important distinction is in the use of folded dipoles in the K. O. antenna instead of the straight dipoles used by Isbell. (See opinion of lower Court, R. 20 and footnote 10). A folded dipole has both an inherently wider bandwidth than does a straight dipole (R. 81, 157, 158) and a higher impedance, *i.e.,* 300 ohms rather than 70 ohms (R. 76, 81).

Prior to Isbell's invention in 1959, the substitution of straight dipoles (narrow-band elements) for the folded dipoles (broad-band elements) of the K. O. antenna would have appeared to one skilled in the art as a step in the wrong direction, if the objective was to increase the bandwidth of the antenna (R. 157). Moreover, such a substitution would apparently have created a great impedance mismatch between the antenna and the twin-lead transmission line, which has an impedance of 300 ohms (R. 60). The substitution of low-impedance narrow-band straight dipoles for high impedance, wide-band folded dipoles would not have been obvious, but rather another step in the wrong direction (R. 157-158).

The unobviousness of this substitution is borne out by the fact that this substitution was never made in the commercial K. O. antenna (R. 127, 128), in spite of the obvious simplification of the antenna structure and the reduction in cost which would have resulted thereby.

Koomans Patent 1,964,189.

The Koomans array shown in U. S. Patent 1,964,189, while directive, is not broad band nor log-periodic. It is a broadside antenna (R. 149), *i.e.,* it transmits or receives radiation at right angles to the plane of the elements, rather than in the plane of the elements, as in both Isbell and Katzin (see Fig. 3). All the dipoles in the Koomans array, moreover, are of uniform length and spacing.

Winegard Patent 2,700,105.

Winegard Patent 2,700,105 only has two driven elements, a minimum of three driven elements being necessary in the design of an Isbell antenna (R. 155). It is not a log-periodic antenna.

The Trial Court Used Hindsight in Considering the References.

In reviewing de novo the references which the Patent Office had already considered, the lower Court succumbed to what Mr. Justice Frankfurter in his dissent in *Marconi Wireless Teleg. Co.* v. *United States,* 320 U. S. 1, (1942), described as that "subtle temptation of taking scientific phenomena out of their contemporaneous setting and reading them with a retrospective eye." He further went on to state:

> "The discoveries of science are the discoveries of the laws of nature, and like nature do not go by leaps. Even Newton and Einstein, Harvey and Darwin, built on the past and on their predecessors. Seldom indeed has a great discoverer or inventor wandered lonely as a cloud. Great inventions have always been parts of an evolution, the culmination at a particular moment of an antecedent process. So true is this that the history of thought records striking coincidental discoveries—showing that the new insight first declared to the world by a particular individual was 'in the air' and ripe for discovery and disclosure.
>
> "The real question is how significant a jump is the new disclosure from the old knowledge. Reconstruction by hindsight, making obvious something that was not at all obvious to superior minds until someone pointed it out,—this is too often a tempting exercise for astute minds. The result is to remove the opportunity of obtaining what Congress has seen fit to make available."

C. THE FINDINGS OF FACT OF THE TRIAL COURT WERE BASED SOLELY ON DOCUMENTARY EVIDENCE AND PHYSICAL EXHIBITS AND ARE NOT BINDING ON THIS COURT.

The trial Court in reaching its decision relied solely on documentary evidence and/or physical exhibits which this Court is in as good a position to consider as the trial Court was. *American Infra-Red Radiant Co.* v. *Lambert Industries, Inc.,* 360 F. 2d 977, 988 (8th Cir. 1966); *State Farm Mut. Automobile Ins. Co.* v. *Bonacci,* 111 F. 2d 412, 415 (8th Cir. 1940). The so-called "documentary" rule has particular application in patent cases. For example, in *Nasco, Inc.* v. *Vision-Wrap, Inc.,* 352 F. 2d 905, 908 (7th Cir. 1965), the Court stated:

> "The appealed decision rests entirely on documentary evidence and physical exhibits. Consequently, the court's findings, in so far as they concern the use made of prior art, the nature of the improvement made over prior art, and the operational functions and characteristics of the patented structure and the accused device, are deprived of the degree of finality which would otherwise attach under Rule 52(a) of the Federal Rules of Civil Procedure. We are in as good a position as the trial court to examine and evaluate the evidence and make the necessary determinations ourselves."

In this case, this exact situation obtains because the lower Court, in arriving at its decision, relied only on certain prior publications and a physical exhibit, *i.e.,* the Channel Master K. O. antenna. Thus, this Court can examine and evaluate the evidence for itself in resolving the issue of obviousness.

D. THE PRINCIPAL REFERENCES RELIED UPON BY THE LOWER COURT WERE ALSO CONSIDERED BY THE PATENT OFFICE IN THE PROSECUTION OF THE ISBELL PATENT.

The presumption of validity of the patent in suit is greatly strengthened since the principal references on which the lower Court relied were considered and rejected by the Patent Office during the prosecution of the Isbell patent. In its initial decision (R. 19), the lower Court acknowledged only the Katzin patent (DX-E-4) as having been so considered. It thereafter* recognized that the DuHamel-Ore publication (DX-A-1) had also been before the Patent Office, but erroneously negated its effect. The trial Court also failed to take into consideration the fact that although the K. O. antenna as a physical exhibit was not before the Patent Office, a full disclosure of its structure was considered in connection with the prosecution of the Isbell patent (R. 176). This disclosure was considered at the same time as the *DuHamel-Ore publication* (R. 176).

In this case, the DuHamel-Ore publication (DX-A-1) and a reference describing the K. O. antenna (R. 175) were cited during interference proceedings involving the Isbell invention, while the K. O. antenna reference was *also* cited against another closely related patent application owned by plaintiff (PX-66) which was being prosecuted at the same time as the Isbell application (R. 159). In both instances, these references were *cited by the same Examiner* (Mr. Eli Lieberman) who allowed the Isbell patent application. These *references* were *not merely* cited as being pertinent but instead were principal references. They were

---

* On plaintiff-appellant's motion to amend the findings (R. 40), the Court modified footnote 14 (R. 25) of its Memorandum Opinion, recognizing that the DuHamel-Ore publication was cited in the Patent Office but erroneously concluding that the patent examiner did not consider it (R. 42).

applied with full force and effect against the issues involved. Specifically, it will be seen that during the interference (R. 145) involving the Isbell application in the Patent Office, the Examiner was called on to decide the patentability of certain additional claims (counts) proposed by the parties. In deciding the issue, the Examiner (Eli Lieberman, who was also the Examiner who ultimately allowed the Isbell application) decided (R. 176) that one of the proposed claims (count 3) was not patentable over the art, and he cited the DuHamel-Ore article and an article describing the Channel Master K. O. antenna in support of his decision. *At the same time, however, the Examiner allowed proposed count 2,* which ultimately appeared as Claim 9 in the Isbell patent (R. 145), *over the same prior art* (R. 146). It is quite apparent that the Examiner was not only aware of the DuHamel-Ore article and the K. O. antenna reference, but also considered the patentability of Isbell's invention with respect to these references, and concluded that the invention was patentable. Accordingly, the lower Court was in error when it concluded that the Patent Office examiner did not consider the DuHamel-Ore and K. O. antenna references in their entirety and on their merits against the Isbell invention.

In addition to the Katzin, DuHamel-Ore, and K. O. references, the Patent Office cited another patent, Koomans British 408,473, to show that crossed feeder lines connecting the elements of an antenna were old (R. 144, 145). Thus, although the Patent Office did not use the same references (*i.e.,* the White, Winegard, and Koomans U. S. patents) on which the trial Court relied for showing that crossed feeder lines were old, the Patent Office nevertheless treated this aspect of Isbell's invention as known in the art.

The references before the Patent Office (DuHamel-Ore, Katzin, K. O. antenna, and Koomans British) include all of the information which the lower Court set forth as being known by the prior art, the other references (*i.e.,* Koomans U. S., White, and Winegard) cited in the Court's opinion being merely cumulative on the matter of transposed transmission lines or varying dipole lengths, and thus having no effect on the presumption of validity of the patent. *Otto* v. *Koppers Co.,* 246 F. 2d 789, 801 (4th Cir. 1957). Under these circumstances it is evident that there was no basis on which to attack the validity of the patent which was not considered and rejected by the Patent Office. The presumption of validity is therefore greatly strengthened. *Dean Rubber Mfg. Co.* v. *Killian,* 106 F. 2d 316, 318 (8th Cir. 1939); *Nasco Inc.* v. *Vision-Wrap, Inc.,* 352 F. 2d 905, 908 (7th Cir. 1965); *Briggs* v. *M & J Diesel Locomotive Filter Corp.,* 342 F. 2d 573, 576 (7th Cir. 1965).

IV. CONCLUSION.

The lower Court made too easy a transition from what was not to what became. In so doing, it erroneously relied on hindsight, which is not the criterion of invention. Accordingly, it is respectfully submitted that the lower Court was in error in holding that the Isbell invention was obvious and its decision should be reversed.

Respectfully submitted,

Charles J. Merriam,
William A. Marshall,
Basil P. Mann,
30 West Monroe Street,
Chicago, Illinois 60603,
Area Code 312-346-5750,
Attorneys for Plaintiff.

Of Counsel:
Merriam, Marshall, Shapiro & Klose,
30 West Monroe Street,
Chicago, Illinois 60603,
Cook, Blair, Balluff & Nagle,
409 Putnam Building,
Davenport, Iowa 52801.

In the

United States Court of Appeals

For the Eighth Circuit

No. 19,000
Civil

UNIVERSITY OF ILLINOIS FOUNDATION,
Appellant,

vs.

WINEGARD COMPANY,
Appellee.

APPEAL FROM THE UNITED STATES DISTRICT COURT FOR THE SOUTHERN DISTRICT OF IOWA, DAVENPORT DIVISION.

APPELLANT'S REPLY BRIEF.

CHARLES J. MERRIAM,
WILLIAM A. MARSHALL,
BASIL P. MANN,
30 West Monroe Street,
Chicago, Illinois 60603,
Area Code 312-346-5750,
Attorneys for Appellant.

Of Counsel:
MERRIAM MARSHALL, SHAPIRO & KLOSE,
30 West Monroe Street,
Chicago, Illinois 60603,
COOK, BLAIR, BALLUFF & NAGLE,
409 Putnam Building,
Davenport, Iowa 52801.

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APPELLANT'S REPLY BRIEF.

INTRODUCTION.

Winegard's brief confuses rather than clarifies the situation and argues positions which were not found by the Court below.

This is particularly unfortunate in a case of this type where the invention is one of electronic complexity and the only one to have anything to gain from confusion is the party winning below. Obviously, if appellee can confuse the issues enough, then it can hope to win merely if this

Court feels that it lacks sufficient understanding of the electronic complexities that it will not disturb the decision below. In order to avoid this danger our opening brief attempted to state the subject matter in terms which any court untrained in electronics could readily understand. Appellee seems to attempt to confuse such understanding and to cast doubts on appellant's approach. We will therefore do our best to reclarify the situation and to comment specifically on the vulnerable positions taken in appellee's brief.

The District Court did not find that the Isbell patent was anticipated by the art. Rather, the Court based its decision entirely on its findings that log periodic designs, variously spaced and sized dipole arrays, and cross-feeding of dipoles had all been used in antennas and that Isbell's specific *combination* of all three was obvious.

As we pointed out in our main brief (pp. 15-17), the premise as to the elements of Isbell's invention is correct only if each of these "elements" is dissected from larger assemblies which dominated and affected the operation of the parts and from which individual parts could not be separated and joined to something else with predictable effects. The conclusion is wrong in either event.

Our position is aptly stated in *Eversharp, Inc.* v. *Fisher Pen*, 204 F. Supp. 649, 662-663 (N. D. Ill., 1961), where the Court stated:

> "In order for one to defeat a meritorious patent it is not enough to pick out isolated features in earlier prior art patents, combine them in one particular way with hindsight acquired only from the patent under attack, and then say that no invention would have been involved in selecting those particular features and combining them in the particular way in which the patentee did."

To say that such dissection and reassembly was obvious to one skilled in the art is improper, when historically it was not obvious to anyone, and the testimony is uncontradicted that one could not predict the effect of such dissection and reassembly.

The difficulty of prediction in the antenna art is aptly illustrated by the testimony of appellee's witness, Dr. Yang. When questioned whether the antenna depicted in a prior reference (White patent 2,105,569; DX-E-3; R. 210) could be made to operate to cover T.V. channels 2-6, Dr. Yang testified (R. 135):

> "Well, I suppose one could, yes, because you know —so far as antenna, I guess it is much more so than any other art or sciences, and your knowledge is really limited, what you know, what you can do, and mostly if you narrow down an area, you are going to cut and try, but then you couldn't cut and try from there on, so I would imagine the people—yes, they would try that and make even feed-back back here, and you could if you find out maybe front end works better than from there, you could, yes."

Appellees have not come to grips with this position but have instead tried to develop a whole new array of diversionary discussions. Winegard now seeks to have this Court go into patents and publications in areas not touched upon by the District Court. We do not consider it proper to ask this Court, in a complex electronic case, to review such new fields.

COMMENTS ON APPELLEE'S BRIEF.

We will comment on Winegard's diversionary tactics individually, even though they have no place in the appeal.

1. At pages 1 to 4 of its brief Winegard says that the Isbell antenna is not the best possible antenna. This we concede. The telephone (see *Telephone* cases, 126 U. S. 1) was a very poor instrument and in fact would operate only occasionally, but this did not have anything to do with its patentability. The Isbell antenna is enough better than anything else that Winegard copied it in spite of the patent.

As the 7th Circuit Court of Appeals said in *Ric-Wil Co.* v. *E. B. Kaiser Co.*, 179 F. 2d 401, 404 (7th Cir. 1950):

> "The prior art upon which defendant now lavishes its praise was apparently permitted to lie dormant until the exigency, created by a suit for infringement, required its resurrection. Defendant's imitation of the patent structure is another indication of invention."

2. The next attack of appellee (pp. 5-6) is directed at appellant's use of the expression "cell" in defining the basic components of the antenna. This can be answered simply by referring to the lower Court's findings of fact in its memorandum opinion.

At R. 22, the court stated:

> "The term 'design cell' is used herein to refer to a structural unit of an antenna which is capable of receiving and transmitting electromagnetic radio energy. *A simple or folded dipole and an adjacent section of transmission line are examples of such antenna design cells.* A particular antenna array may be composed of one or more similar or dissimilar design cells." (Emphasis added.)

This is a finding of fact made by the lower Court which is uncontroverted by the evidence and is not attacked.

3. The list of things which Isbell did not invent (page 7 of Winegard's brief) omits the wheel, motherhood, and other things which are equally irrelevant, and which Isbell did not claim to invent. The question is not what he did not invent but what he *did* invent and claim.

Winegard has attempted to draw multiple red herrings by this type of an approach. Not only are these irrelevancies cited and emphasized, but great emphasis is placed upon the alleged endeavors of Mr. Winegard. One would be led to think from reading pages 3 and 4 of appellee's brief that Winegard's prior activities produced the patented antenna. Winegard of course knows that this was not so. The early Winegard Colorceptor antenna* has not been charged to infringe, is still sold by Winegard, and can still be bought by anyone who wishes a noninfringing antenna rather than an antenna having the excellent performance characteristic of the patented antennas.

4. On page 10 appellee's counsel say that they are not aware of any difference in the rule of nonobviousness in electronic as compared to mechanical cases. The difficulty which they have is in distinguishing between *standard* of invention and the ordinary *skill* of the art. We agree that the statutory standard of nonobviousness is the same for all inventions but assert that the ability to predict is far less in the electrical arts than in the mechanical arts. The Supreme Court agrees with this, as pointed out at page 12 of our opening brief, where we quoted from the *Great A & P Tea Co.* v. *Supermarket Equip. Corp.*, 340 U. S. 147 (1950).

* This antenna is described in Winegard patent 2,700,215. (R. 201.)

The quoted language from the *A & P* case is followed in an electrical case, *U. S.* v. *Adams,** 383 U. S. 39, 50 (1966) relating to a nonrechargeable electrical battery. The Supreme Court stated that the battery embraced "elements having an interdependent functional relationship."

In that case the infringer took the position that each of the elements of the Adams battery was old and could be combined by one skilled in the art without providing a patentable invention. This position was rejected by the Court.

The *Adams* case is precisely applicable to the present facts where it was admitted by the experts on both sides that one could not predict the interdependent functional relationship of the elements of the patented antenna because, for example, every time a dipole array is charged, or the interconnection between the dipoles is varied, or the feed point of the antenna is modified, a different functional electronic relationship is established between the combined elements. Cause and effect in the properties of the resultant combination is generally so complicated that one cannot predict ultimate results with reasonable certainty. This is gone into more deeply in our opening brief pages 12 to 25.

No such problem arises in the ordinary mechanical case. When one reverses the hinged position on a plow (*Graham* v. *Deere*) or modifies the design of a spray can top (*Calmar* v. *Cook*), it usually does not take extraordinary skill to predict the effect. Neither are there so many combinations that it is impossible to try them all, even if the results could not be predicted.

* This was one of the three most recent patent cases decided by the Supreme Court, the other two being *Graham* v. *John Deere*, 383 U. S. 1, and *Calmar* v. *Cook Chemical*, 383 U. S. 26. The *Graham* and *Calmar* cases involved mechanical patents which were held invalid. In the *Adams* case an electrical patent was held valid.

On the other hand, in an electronic system such as this, where every change affects every other element, the possible combinations are infinite, and the effect of the changes is not predictable.

5. At pages 15 to 19 of its brief, Winegard proposes a fanciful series of substitutions and alterations in DuHamel and Ore devices, using figures which are not those of the article.

Figure C of the brief is not Figure 15 of the article, as it claims to be (see R. 185). While Figure C has some similarity to Figure 15 of the article, the differences are more significant than the similarities. In particular, the illustration in the brief omits the rigid device clearly shown in Figure 15 which holds the two elements apart. Instead appellee's brief uses an indication which to the ordinary person might indicate a collapsible or hinged device. This is obviously to give the impression that the next alteration dreamed up by Winegard, namely that the device should be collapsed so that the parts are together, would seem more plausible. Winegard then assumes that instead of the zigzag device of the article the Isbell dipoles are substituted.

There is no teaching in the article to make these alterations of the DuHamel and Ore structures, and no finding in the decision below that such alterations would have been obvious. On the contrary, See the language of Winegard's expert quoted at p. 3 above.

It is always possible by hindsight to single out pieces from here and there and reassemble them. Anyone can go to the dictionary and pick out the words of the Gettysburg Address.

Not only was there nothing leading to the changes suggested by appellee from the thousands of available possibilities, but the actual directions of the article would have to be disregarded to make them, since DuHamel and Ore specified (R. 178, column 1, lines 20 and 21) that "all dimensions are made proportional to their distance from the vertex." The synthetic device shown in Figure E on page 18 of Winegard's brief does not conform to this teaching.

6. Winegard says in the last paragraph on page 19 that the concluding statement on page 20 of our brief is contradicted by the evidence. Conveniently Winegard leaves out any record citation to this blanket charge and in fact completely misinterprets not only Mr. Harris's testimony (R. 148, 149) but also that of its own expert, Mr. Yang, who did not answer the question posed at SR. 80, but merely said there is "something of a drawback of the log periodic antenna." This is no contradiction of our statement. It should be noted that the court made no finding contrary to our statement (Cf. R. 17, 18, 26).

We did not cite other record references, either, because this is such an elementary statement that we did not conceive that anyone would deny it no matter how partisan he might be. The undisputed cited testimony of Messrs. Turner and Harris relied upon by appellant establishes this point (R. 108, 111, 148, 149).

7. At page 22 of our brief we discussed the Katzin patent, which the District Court found showed straight dipoles with progressively varied lengths and spacing (R. 20). As we pointed out, this alone did not meet Isbell because of the failure to have a crossed-over feeder directly coupled to the dipoles, plus the fact that Katzin was an "endfire" antenna and the Isbell is a "backfire" antenna. The illustration at page 23 of our brief shows the differences in operation.

At page 21 of its brief Winegard attempts to confuse the issue as to "endfire" and "backfire" antennas. In proper terminology, Isbell is a backfire antenna which receives its signal from the end of the antenna with the *shortest* dipoles. Katzin is an endfire antenna which receives its signal from the end of the antenna with the *longest* dipoles. Katzin operated with its *longest* dipoles toward the signal and Isbell with the *shortest.* The basis for Winegard's statements arises from loose terminology by Mr. Winegard, which even he admitted (SR. 91) could be in error. No one, however, disputes the fact that Katzin operated with his longest dipoles toward the signal, and Isbell the opposite.

Neither does any one dispute the fact that Katzin lacks the crossed-over feeder lines used by Isbell.

Winegard disputes our statement that Katzin also lacks direct coupling to the dipoles. This point is insignificant, although Dr. Mayes testified (R. 154) that Katzin's connections were not direct electrical connections which would permit an unimpeded flow of current as in Isbell.

8. At pages 22 to 25, Winegard treats the K. O. antenna referred to by the District Court as being an anticipation, whereas the Court below merely found that this was an example of one of the so-called elements which the Court combined to reach its finding of obviousness. The Court in fact specifically found (R. 20) that the K. O. antenna used *folded* dipoles and not the simple dipoles of Isbell.

Winegard at page 24 quibbles over whether the record shows that the K. O. antenna was never made with simple dipoles. Its position is that the record is ambiguous. Since the burden was on Winegard to show that K. O. antenna was made with simple dipoles there is no point to the argument.

9. The Winegard and Koomans patents (discussed on page 25 of appellee's brief) were similarly relied on by the lower Court (R. 21, 24) simply as showing the use of transposed feeder lines in antennas which were otherwise differ-

ent from Isbell's, and for no other purpose. We do not, as defendant alleges, say that the Winegard and Koomans patents are not pertinent, but rather that they are merely cumulative and add nothing to the teachings or suggestions of the prior art cited by the Patent Office.

Similarly, we did not discuss the White patent at any length in our opening brief because it, too, is merely cumulative in showing transposed feeder lines and dipoles eleelements of varying lengths (R. 21). The White antenna, however, differs from Isbell's in that it is fed at the center of the antenna, as the Court found (R. 21), rather than at the end with the smallest dipoles, as is the case with Isbell's antenna. The Court below apparently shared our feeling that the White patent was relatively insignificant, since it did not refer at all to this patent in its discussion of the obviousness of the Isbell patent (R. 24, 25).

10. Appellee says on page 30 of its brief that it does not "know" whether the DuHamel-Ore article (R. 177), referred to in the Patent Office interference proceedings involving the Isbell patent, is the same as the article relied on by Winegard as a prior art publication. The District Court first held (R. 26) that the Patent Office was not aware of the DuHamel-Ore article, and then, on Appellant's motion, amended its opinion to say that although the article was referred to by the Patent Office, it was not considered by the Patent examiners (R. 42).* Appellee, at the time of Appellant's motion, did not deny the identity of the two articles. Since Appellee has gone outside the record to say what it doesn't know, we have attached both articles hereto as an appendix. The articles are identical, and we question appellee's statement that it did not know this.

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* Appellant still maintains that, even as amended, this statement of the Court is clearly erroneous (Appellant's brief, p. 28, *et seq.*)

The *Monroe Auto Equip.* case cited by appellee (p. 34) is inapposite. In that case there were separate patents involved. In this instance, the interference proceedings in which the DuHamel-Ore publication was cited were part of the proceedings *during* the prosecution of the Isbell patent. Obviously the interference proceeding would be part of the Isbell file history. Appellee knew this, having introduced into evidence portions therefrom, but conveniently having left out the relevant portion. Yet it ignores this in its conclusory remarks on page 35 of its brief.

11. Appellee also questions at page 27 whether or not this Court should review the trial Court's decision. This Court in *General Mills* v. *Pillsbury,* 378 F. 2d 666 (8th Cir. 1967) pointed out that validity is a question of law and proceeded in the manner requested in this case. See also *Payne Metal Enterprises, Ltd.* v. *McPhee,* 383 F. 2d 541 (9th Cir. 1967). Even if the Court's finding as to what was old were accepted, the conclusion drawn therefrom as to obviousness is a matter of law and is challenged.

12. Winegard points out that there were numerous issues raised by it which were not the basis for the District Court's opinion. In the absence of a cross appeal by Winegard as to these specific issues, it would seem that these points must have been discarded by the District Court and their rejection accepted by Winegard.

CONCLUSION.

While there are other points raised by Winegard in its "bag of smoke", appellant, in not replying, should not be considered as acquiescing in them. Counsel repeatedly accuse us of having made misleading statements or cited "half truths". On examination, it will be found that in each instance appellee has implied something into our statements which was not there, and then sought to say that this implication was misleading. Unfortunately, few statements can be made so clear that this type of sniping can be avoided. We have gone over our initial statements in light of these charges and find that the original brief was accurate and that the charges, not the brief, are misleading.

Respectfully submitted,

Charles J. Merriam,
William A. Marshall,
Basil P. Mann,
30 West Monroe Street,
Chicago, Illinois 60603,
Area Code 312-346-5750,
Attorneys for Appellant.

Of Counsel:
Merriam Marshall, Shapiro & Klose,
30 West Monroe Street,
Chicago, Illinois 60603,

Cook, Blair, Balluff & Nagle,
409 Putnam Building,
Davenport, Iowa 52801.

APPENDIX INDEX.

APPENDIX A.

CTR-198

LOGARITHMICALLY PERIODIC ANTENNA DESIGNS

R. H. Du Hamel

and

F. R. Ore

31 March, 1958

A PUBLICATION OF
THE RESEARCH AND DEVELOPMENT DIVISION

COLLINS RADIO COMPANY

CTR-198

31 March, 1958

COLLINS TECHNICAL REPORT

LOGARTHMICALLY PERIODIC ANTENNA DESIGNS

R. H. Du Hamel
and
F. R. Ore

Cedar Rapids, Iowa

COLLINS

COLLINS RADIO COMPANY

A PUBLICATION OF

THE RESEARCH AND DEVELOPMENT LABORATORIES

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LOGARITHMICALLY PERIODIC ANTENNA DESIGNS

R. H. DuHamel and F. R. Ore
Collins Radio Company
Cedar Rapids, Iowa

Summary

Research on new types of broadband logarithmically periodic antenna structures is reported. The antennas have pattern and impedance characteristics which are essentially independent of frequency over theoretically unlimited bandwidths. Bandwidths of ten to one are readily achieved in practice. Structures are described which provide linearly polarized omnidirectional, bidirectional and unidirectional patterns as well as circularly polarized bidirectional and unidirectional patterns.

Introduction

The subject of this paper is a class of antennas, called logarithmically periodic antenna structures, for which the pattern and impedance are essentially independent of frequency over theoretically unlimited bandwidths. Research on one particular type of these structures which provided a linearly polarized bidirectional beam was previously reported.[1] Since that time, various types of these structures have been discovered which provide linearly polarized unidirectional and omnidirectional patterns as well as circularly polarized unidirectional patterns. The proven versatility and wide bandwidth of these structures leads to the conclusion that the applications are practically unlimited. Obvious applications are to high-frequency and ECM antennas as well as to primary feeds for reflector and lens-type antennas.

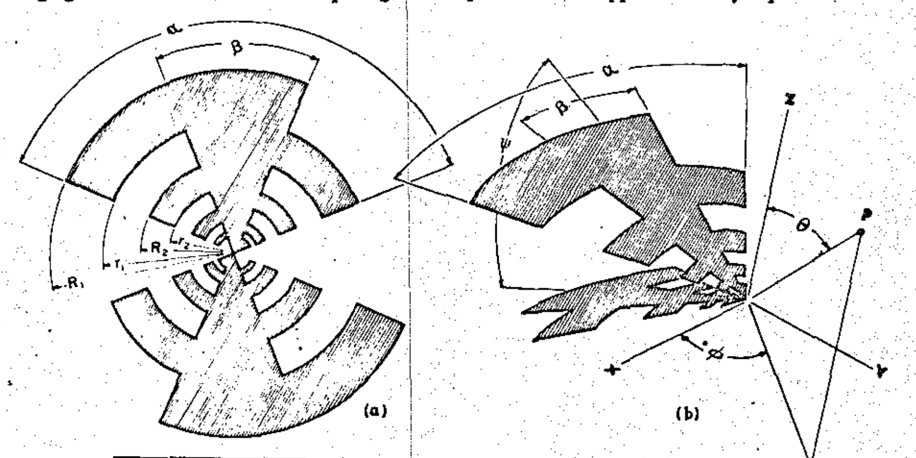
The only other known class of frequency independent antennas is the angular antenna described by V. H. Rumsey.[2] Common examples are the discone, biconical, and bow-tie antennas which have bandwidths of approximately 2 or 3 to 1 for which the pattern is essentially independent of frequency. The so-called "end effect" limits the bandwidth of these antennas. An example of a recent type of angular antenna which apparently has negligible "end effect" is the equiangular or logarithmic spiral antenna[3] which has a frequency independent bandwidth of better than 10 to 1.

Referring to figure 1, the geometry of logarithmically periodic antenna structures is defined so that the pattern and impedance repeat periodically with the logarithm of the frequency. For planar structures, this is accomplished by defining their shape such that θ equals a periodic function of ln r where r and θ are the polar coordinates in the plane. Then if ln τ is the period of ln r, the operation of a structure of infinite extent would be the same for any two frequencies related by some integral power of τ. For the simple structure in figure 1a:

$$\tau = \frac{R_{N+1}}{R_N}$$

If the shape of the structure and the factor τ can be made such that the variation of the pattern and impedance over one period is small, then this will hold true for all periods, the result being an extremely broadband antenna. For finite structures, it has been found that since the end effect is negligible, wide bandwidths are readily obtained.

The two halves of the antenna are fed at the vertices either with a balanced two-wire line or with a coaxial line running up one half of the structure with the outer conductor bonded to the structure. For the structure of figure 1a, it is found that the lower and higher frequency limits are obtained when the longest and shortest teeth respectively are approximately 1/4 wavelength long. By probing the structure, it is found that the currents on the structure die off quite rapidly after progressing past the region where a tooth 1/4 wavelength long is positioned. This accounts for the negligible end effect. This antenna has a horizontally polarized bidirectional pattern with approximately equal and constant principal



$\tau = \frac{R_{N+1}}{R_N}$	$\alpha = 135°$
	$\beta = 45°$
$\sigma = \frac{r_N}{R_N}$	$\tau = .5$

Figure 1. Parameters and Coordinate System for Circular Tooth Structures

plane beamwidths over a frequency band of 10 to 1 or more and has a constant input impedance of approximately 170 ohms. The axes of the lobes are perpendicular to the plane of the structure. It was originally believed that it was necessary to make these structures identical to their complement in order to obtain a frequency independent input impedance. However, the results reported in this paper demonstrate that this equi-complementary condition is sufficient but not always necessary. Several frequency independent antennas will be introduced where the deviation from the equi-complementary condition is quite severe.

The fact that the electrical characteristics of logarithmically periodic structures repeat every period greatly simplifies the experimental investigation of them because it is only necessary to measure these characteristics over a half or single period in most cases. The operation over other periods may be readily predicted provided the end effect is negligible and that all dimensions are made proportional to their distance from the vertex.

As illustrated in figure 1b, D. E. Isbell[4] found that by bending the curved tooth structure about a horizontal axis, a unidirectional pattern pointing in the direction of the positive y axis could be obtained. Some control of the principal plane beamwidths and front-to-back ratio was obtained by varying the parameters α, β, ψ, and τ. Typical E-plane and H-plane beamwidths of 60° and 90° and a front-to-back ratio on the order of 10 to 15 db were obtained. It was found that the characteristic impedance of the structure decreased as the angle ψ was decreased, but that the VSWR referred to this characteristic impedance increased rather rapidly to 3.5:1 for ψ = 30°.

A great number of logarithmically periodic antenna configurations are possible. The investigation reported in this paper was conducted to study impedance, pattern, and polarization characteristics of a variety of structures. Another objective of the investigation was to devise practical forms of this type of antenna. Since large circular tooth structures would be difficult to construct, the possibility of simplifying this basic structure by straightening the teeth and by making wire approximations of the teeth was investigated and is reported in the following sections.

Trapezoidal Tooth Sheet Structures

Figure 2 shows a sketch of a general trapezoidal tooth structure and gives a definition of the coordinate system and various parameters that will be used throughout this paper to describe the various structures. Figure 3 is a photograph of a printed circuit board form of this type of structure which was used for the experimental investigation. By comparing a structure cut from sheet metal in a conventional way to an identical structure etched on teflon dielectric printed circuit

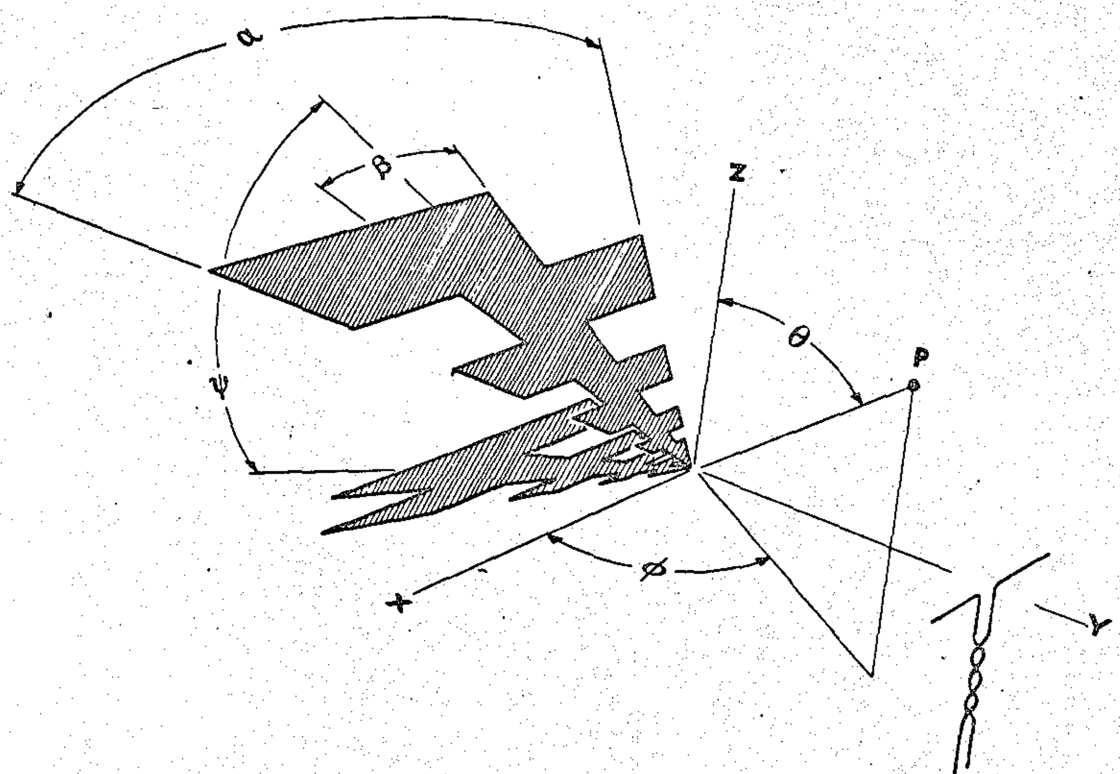


Figure 2. Parameter and Coordinate System for Trapezoidal Tooth Structures

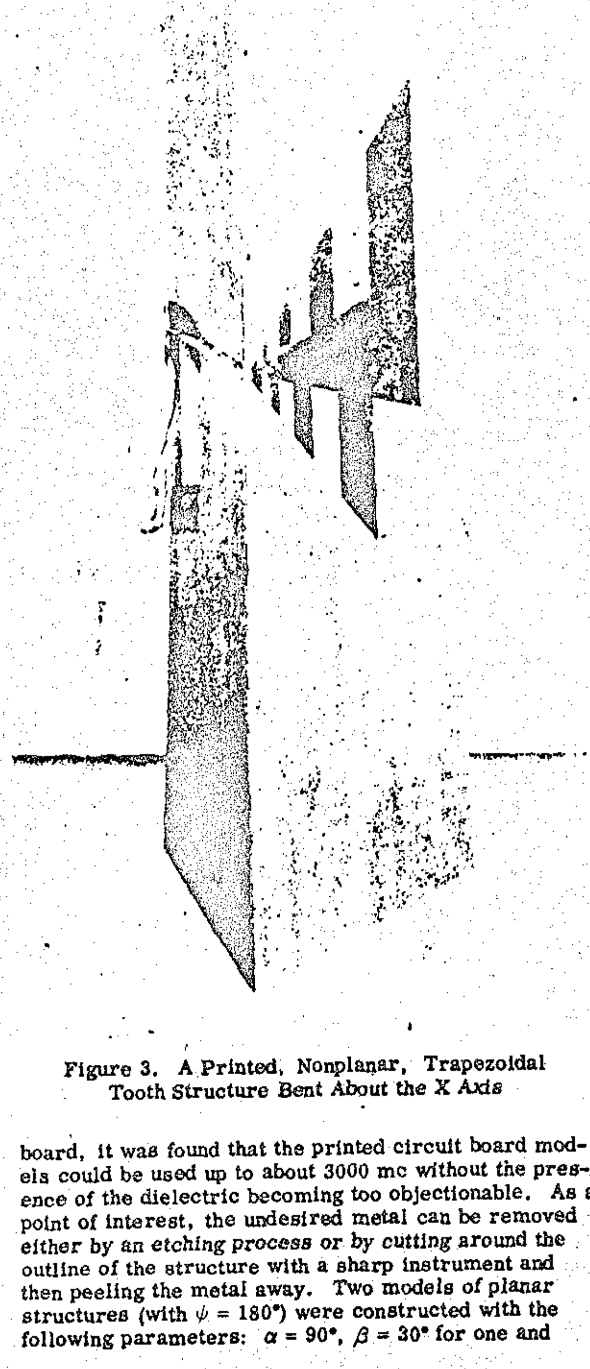


Figure 3. A Printed, Nonplanar, Trapezoidal Tooth Structure Bent About the X Axis

board, it was found that the printed circuit board models could be used up to about 3000 mc without the presence of the dielectric becoming too objectionable. As a point of interest, the undesired metal can be removed either by an *etching process or by cutting* around the outline of the structure with a sharp instrument and then peeling the metal away. Two models of planar structures (with $\psi = 180°$) were constructed with the following parameters: $\alpha = 90°$, $\beta = 30°$ for one and

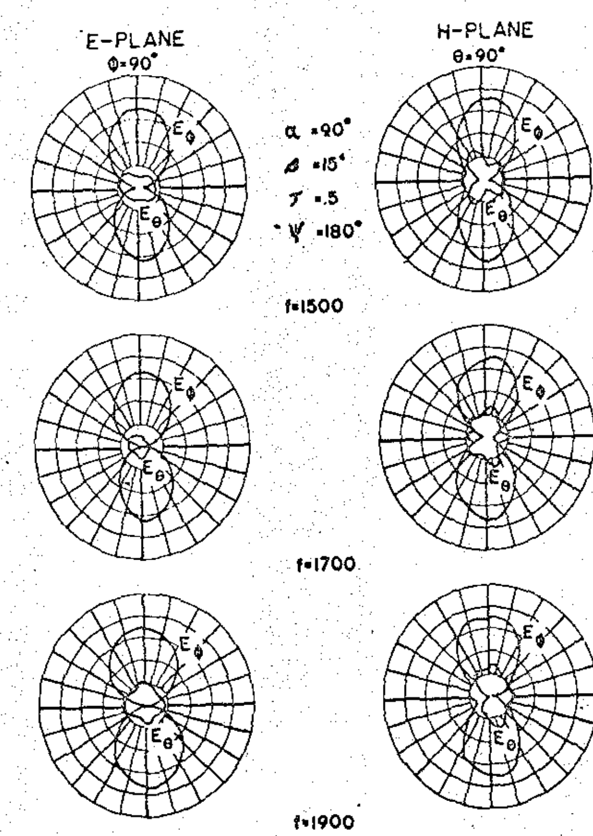


Figure 4. Patterns for Planar Trapezoidal Tooth Structure

$\beta = 15°$ for the other, $\tau = 0.5$, and R_1, the perpendicular distance from the vertex *of one-half the structure* to the longest element, is 12.75 cm. Patterns were taken over about a two to one frequency range (900 to 2100 mc). Figure 4 shows typical patterns for this type of structure. In general, both structures gave essentially *frequency independent, linearly polarized*, bidirectional patterns. Over the frequency range stated above, the E-plane (pattern in the xy plane of figure 1b) half-power beamwidth varied from 65° to 80° with an average beamwidth of 71°, and the H-plane (pattern in *the yz plane of figure 1b) half-power beamwidth* varied from 60° to 69° with an average beamwidth of 62°. Of the two antennas tested, the one having the narrower center section ($\beta = 15°$) demonstrated slightly less variation of beamwidth with frequency.

Patterns were taken for a nonplanar structure with $\psi = 60°$ over a 5:1 frequency range. Typical patterns are shown in figure 5. The E-plane patterns were unidirectional with beamwidths that varied from 60° to 75° with an average beamwidth of 65° and the *H-plane patterns* had beamwidths that varied from 80° to 110° with an average beamwidth of 85°. The front-to-back ratio, due *to the cross* polarization E_θ, had an average value of about 9 db; the front-to-back ratio, due to the major polarization E_ϕ, had an average value of about 13 db.

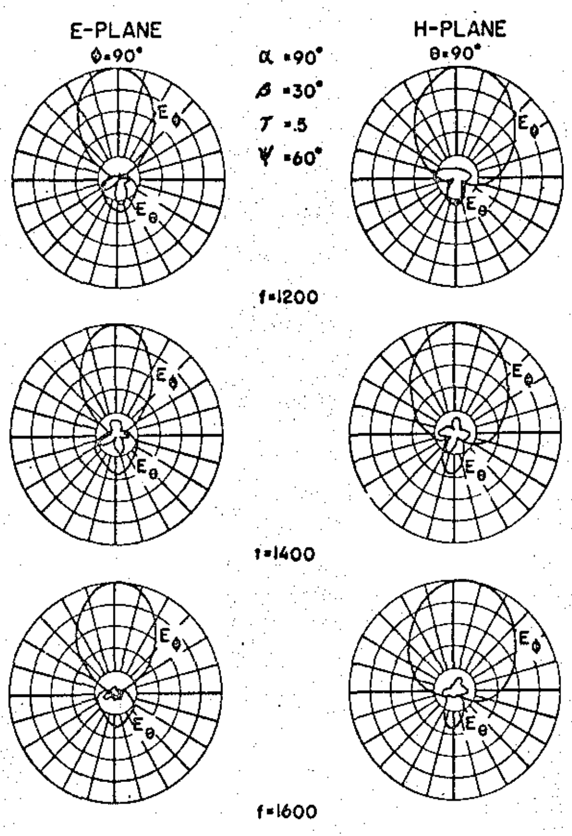


Figure 5. Patterns for Nonplanar (Bent About Horizontal Axis) Trapezoidal Tooth Structure

TABLE 1: VARIATION OF Z_0 AND VSWR WITH ψ ANGLE FOR A PRINTED, TRAPEZOIDAL TOOTH STRUCTURE

ψ Angle	Z_0	VSWR (Referred to Z_0)
180	170	1.4
60	105	1.6

Table 1 shows how the impedance of this particular structure compared with the corresponding planar structure. The input impedance Z_0 was reduced from 170 ohms to about 105 ohms and the VSWR's referred to their respective input impedances were about the same. Thus, the impedance characteristic of a nonplanar trapezoidal tooth structure is considerably better than that of a curved tooth structure.

Another possible nonplanar structure is where the original planar structure is bent about its vertical axis to an included acute angle χ. A structure of this type is shown in figure 6. Patterns and impedance were measured for a variation in χ from 180° to 60° in 30° steps. It was found that the E-plane patterns showed a definite tendency toward varying from bidirectional at χ = 180° to omnidirectional at χ = 60°; the H-plane patterns remained bidirectional over the same range.

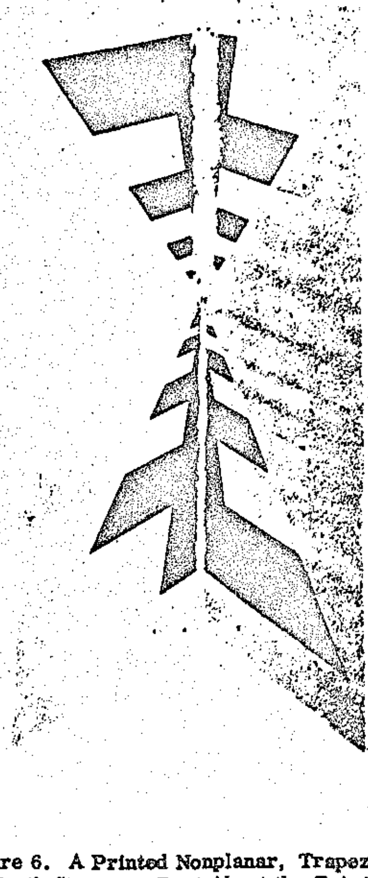


Figure 6. A Printed Nonplanar, Trapezoidal Tooth Structure Bent About the Z Axis

Typical patterns for χ = 90° are shown in figure 7. In general, the patterns varied considerably with frequency.

TABLE 2: VARIATION OF Z_0 AND VSWR WITH VARIOUS χ ANGLES FOR A PRINTED, TRAPEZOIDAL TOOTH STRUCTURE

χ Angle	Z_0	VSWR (Referred to Z_0)
180	170	1.4
120	180	1.35
90	200	1.4
60	210	1.9

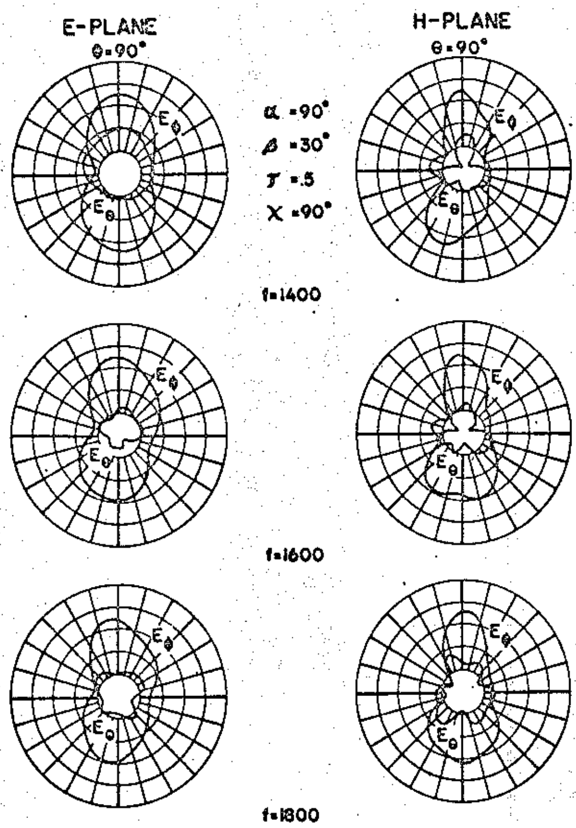
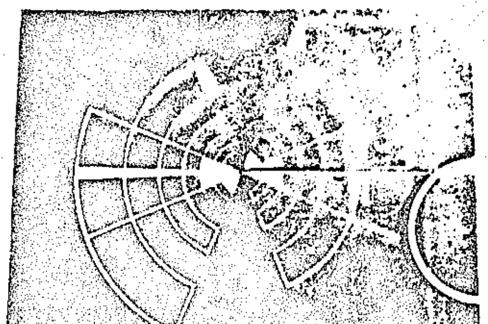
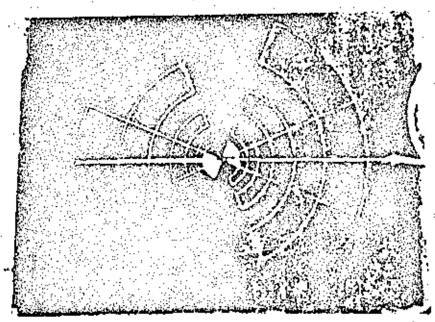


Figure 7. Patterns for Nonplanar (Bent About Vertical Axis) Trapezoidal Tooth Structure



(a) With Tapered Elements



(b) With Uniform Elements

Figure 8. Planar, Printed, Wire Like, Circular Tooth Structure

The variation of impedance with the angle χ was rather interesting, as can be seen in table 2. The average input impedance Z_0 increased as the χ angle was decreased. This was just the reverse of the effect that the reduction in ψ produced.

Wire Structures

Wire, Curved Tooth, Planar Structure

The approximation of sheet structures with wire structures was first investigated for a circular tooth structure. Two different approximations are shown in figure 8 and as can be seen, all the metal was removed except for narrow strips outlining the teeth. A still closer observation will indicate that the horizontal metal strips in figure 8a vary in width proportional to the distance from the center of the structure and the vertical members are triangular in shape. This is necessary in order to make the structure logarithmically periodic. Figure 8b is a structure identical to that of figure 8a, except that all members are of uniform width.

The average input impedance of the structure in figure 8b was slightly lower than that in figure 8a, 110 ohms for figure 8b as compared to 150 ohms for figure 8a. As an interesting comparison, the impedance of a similar basic circular tooth structure was about 150 ohms.

In general, the patterns for the two cases were very similar. In both cases, the patterns were essentially independent of frequency, with the structure having tapered elements being slightly less frequency sensitive. The beamwidths in both the above cases were slightly wider than the beamwidth of the corresponding basic circular tooth structure.

Nonplanar, Wire, Trapezoidal Tooth Structure

Since the circular tooth structures with only the outline of the teeth being made of metal performed almost as well as the basic circular tooth structure, this technique was used in constructing the trapezoidal tooth structures. In figures 9a and 9b are two typical types of wire, nonplanar, trapezoidal tooth structures. The only difference is that in figure 9a, the β angle has

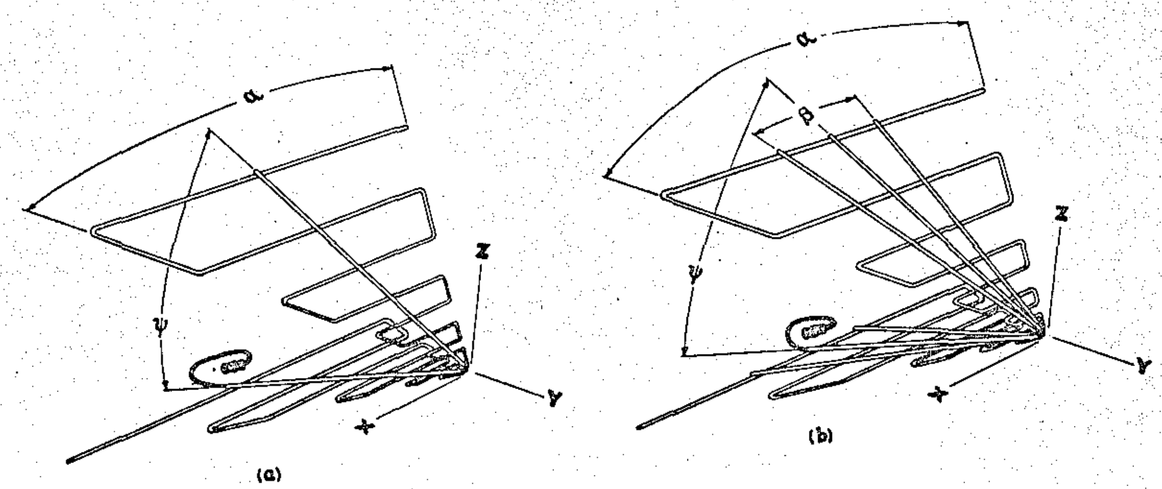


Figure 9. Types of Nonplanar, Wire, Trapezoidal Tooth Structures

been decreased to zero. Figure 10 is a photograph of a typical model used in the investigation of this type of structure. (In the photograph, the dielectric rod between the halves of the antenna was used for support only and is not part of the antenna.)

A considerable number of models of this type of structure with various values of the parameters α, ψ, and τ were constructed and tested. In general, the patterns of these structures were quite independent of frequency, especially those with the larger values of τ. Variations of the beamwidth of only several percent over a period of operation were common.

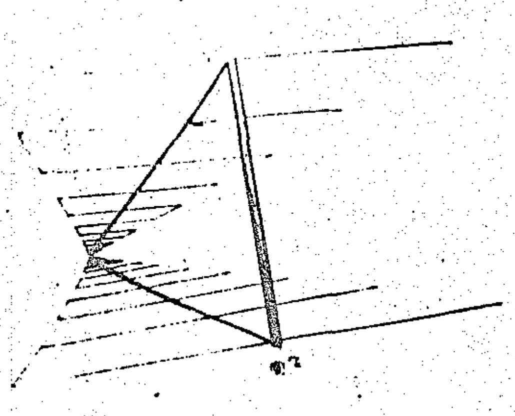


Figure 10. A Typical, Wire, Nonplanar, Trapezoidal Tooth Structure

Figure 11 shows the patterns over a half-period for the antenna shown in figure 10. This particular antenna had an average E-plane beamwidth of 67°, an average H-plane beamwidth of 106° and an average front-to-back ratio of 15 db.

Table 3 shows how the beamwidth, gain, and front-to-back ratio are functions of the parameters of the antenna for several structures. From the table, it can be seen that both E-plane and H-plane beamwidths decrease as the design ratio of τ is increased. For example, take $\psi = 45°$, $\alpha = 60°$; then as τ was varied from 0.4 to 0.707, the E-plane beamwidth decreased from 86° to 64°, and the H-plane beamwidth decreased from 112° to 79°. It can then be concluded that if high gain is required, a large design ratio is desirable. It was found that the spacing between two adjacent transverse elements should not be greater than 0.3 of the length of the longer element. Otherwise, the pattern starts breaking up. Also, from the table it can be seen that the H-plane beamwidth increased with a decrease in ψ angle for any one design ratio, while the E-plane pattern is essentially independent of the ψ angle. Also, the front-to-back ratio, in general, increased with a decrease in ψ angle. The α angle had a second-order effect on the beamwidth; with an increase in α, a decrease in E-plane beamwidth and an increase in H-plane beamwidth resulted.

In using the information in table 3 to design an antenna with relatively high gain, high front-to-back ratio, not too great complexity (the number of elements increases as the design ratio increases), one must make a compromise as to what parameters to choose. For example, antenna number 14 has $\alpha = 60°$, $\beta = 0$, $\psi = 45°$, and $\tau = 0.6$. The gain is 6.5 db over a dipole and the front-to-back ratio is 15.8 db.

These pattern characteristics compare very favorably with those of a three-element Yagi antenna. Admittedly, this type of structure is somewhat more complex to construct than a Yagi, insofar as the number of elements required is greater, and it is necessary to use either a tapered coax line or a balanced open wire transmission line transformer in order to match the impedance of the structure to conventional transmission lines. It has, however, the added advantage of having

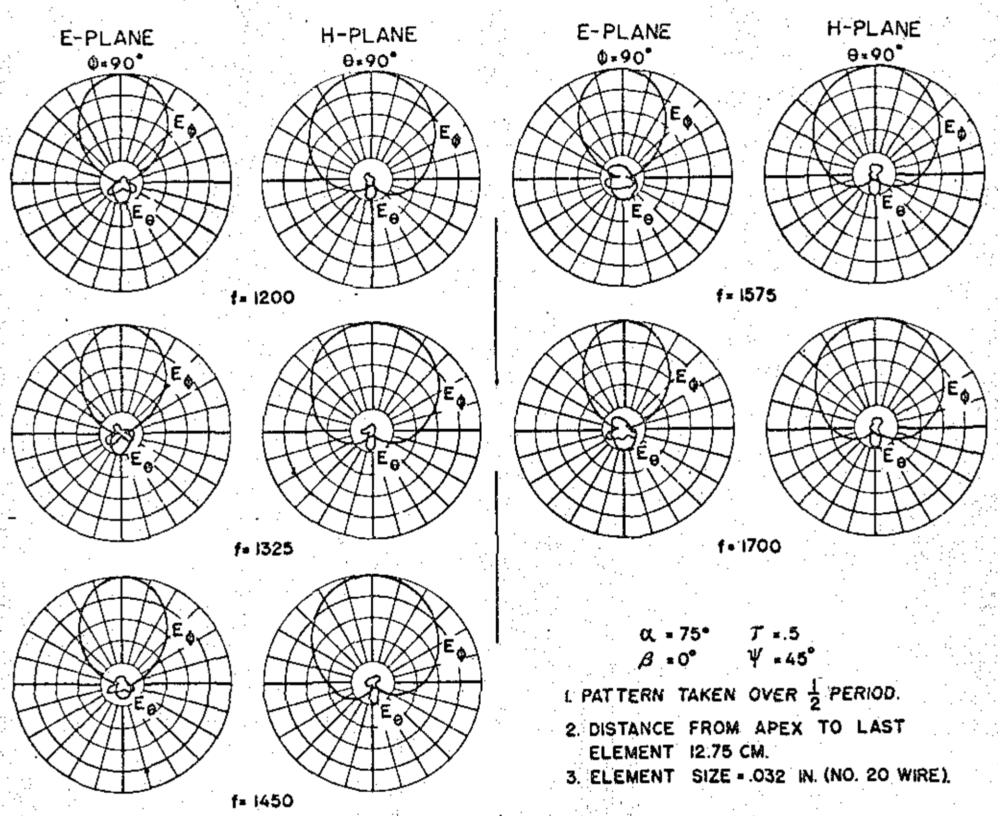


Figure 11. Patterns for a Typical Wire, Nonplanar, Trapezoidal Tooth Structure

TABLE 3. PATTERN CHARACTERISTICS FOR VARIOUS WIRE, TRAPEZOIDAL TOOTH STRUCTURES

ANT	PARAMETERS α	τ	ψ	AVE. HALF POWER BEAM WIDTHS IN DB E PLANE	H PLANE	APPROX. GAIN/DIPOLE IN DB	MAX. SIDE LOBE LEVELS IN DB
1	75	.4	30	74	155	3.5	12.4
2	75	.4	45	72	125	4.5	11.4
3	75	.4	60	73	103	5.3	8.6
4	60	.4	30	85	153	3.0	12.0
5	60	.4	45	86	112	4.2	8.6
6	60	.4	60	87	87	5.3	7.0
8	75	.5	30	66	126	4.9	17.0
9	75	.5	45	67	106	5.6	14.9
10	75	.5	60	68	93	6.1	12.75
11	60	.5	30	70	118	4.9	17.7
12	60	.5	45	71	95	5.8	14.0
13	60	.5	60	71	77	6.7	9.9
14	60	.6	45	67	85	6.5	15.8
15	60	.707	45	64	79	7.0	15.8
16	45	.707	45	66	66	7.7	12.3

essentially frequency independent impedance and pattern characteristics over a ten to one or more bandwidth.

The patterns of a larger antenna model, with the above design parameters *(see figure 12) were* measured over a ten to one frequency range (100 to 1000 mc). A slight increase in the beamwidths and a slight decrease in the front-to-back ratio was observed at about 300 mc. This effect was investigated by taking patterns of the structure and removing the elements one by one. It was found that the elements whose lengths were about 1.5 λ were responsible for these pattern changes. *Thus, some* end effect was noticeable for this structure at a frequency approximately three times the low frequency *limit of the antenna.*

TABLE 4. VARIATION OF AVERAGE IMPEDANCE AND VSWR WITH ψ ANGLE FOR A TYPICAL, WIRE, TRAPEZOIDAL TOOTH STRUCTURE

ψ Angle	Z_o	VSWR (Referred to Z_o)
60	120	1.4
45	110	1.45
30	105	1.5
7	65	1.8

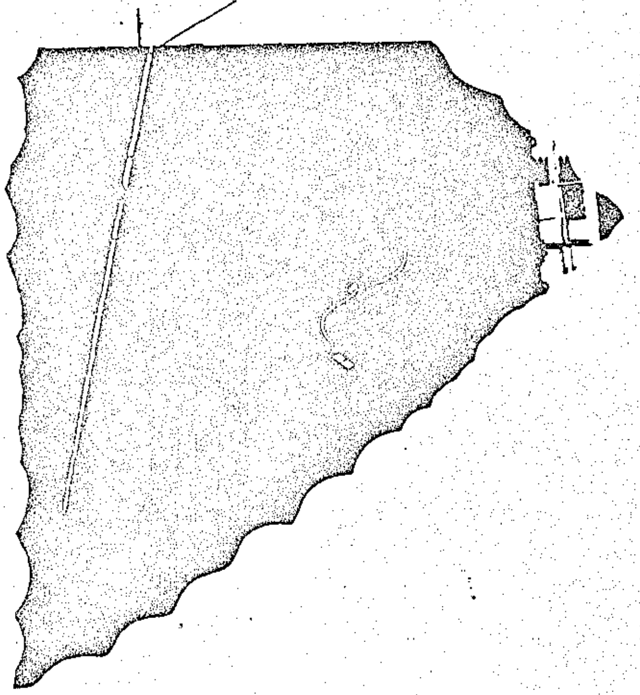


Figure 12. A Larger Model of a (Low Frequency Limit of About 100 Mc) Wire, Nonplanar, Trapezoidal Tooth Structure

Table 4 shows how the impedance varies with the ψ angle for a typical *wire, trapezoidal tooth structure.*

The impedance of the wire, trapezoidal tooth structure (shown in figure 10) having the following parameters: $\alpha = 75°$, $\beta = 0$, $\tau = 0.5$, $\psi = 45°$, and $R_1 = 12.75$ inches, was measured over a sixteen to one frequency band (250 to 4000 mc). The impedance was good from 350 mc to 4000 mc or an eleven to one frequency band. This closely agrees with the previous definition of the low frequency limit since the width of the structure at the last element was *19.5 inches or a half wavelength at* 304 mc. The actual measurements showed that the input impedance Z_o decreased slowly and uniformly from about 150 ohms at 350 mc to about 75 ohms at the high end of the range of measurements. This change in input impedance is due to the modeling technique rather than a fault of the antenna. The elements of this particular model were of constant diameter (# 14 wire) and as the frequency was increased, the length-to-diameter ratio of the elements which were responsible for the radiation *decreased. As further proof that modeling was* partially responsible for this Z_o change, the impedance of another larger model, figure 12, where the elements had been slightly tapered, was measured over a ten to one frequency range. Although the Z_o of this structure also decreased as the frequency increased, the change was somewhat smaller. Thus, in order to obtain good frequency independence over a 10:1 bandwidth, *it is* necessary to model the structure accurately according to the design principles.

Figure 13. A Long (2 λ at 1000 Mc) Nonplanar, Wire, Trapezoidal Tooth Structure

From the observed trends indicated *in table 3,* an antenna with relatively high gain was designed. The model was constructed as shown in figure 13. The parameters *for this particular* model were $\alpha = 14.5°$, $\beta = 0$, $\tau = 0.85$, $\psi = 29°$ and $R_1 = 60$ cm. In order to make the vertical spacing between horizontal elements of the same length of the two half-structures about twice the length of the particular elements, ψ was set equal to 29°. R_1 was chosen equal to 60 cm in order to make the last element one half-wavelength long at 1000 mc. The patterns for *this structure are shown* in figure 14. The average E-plane beamwidth was 59°; the average H-plane beamwidth was 38°; and the *front-to-back ratio* was about 18 db. The resulting gain of this antenna then was slightly better than 10 db over a dipole, and the patterns were extremely frequency

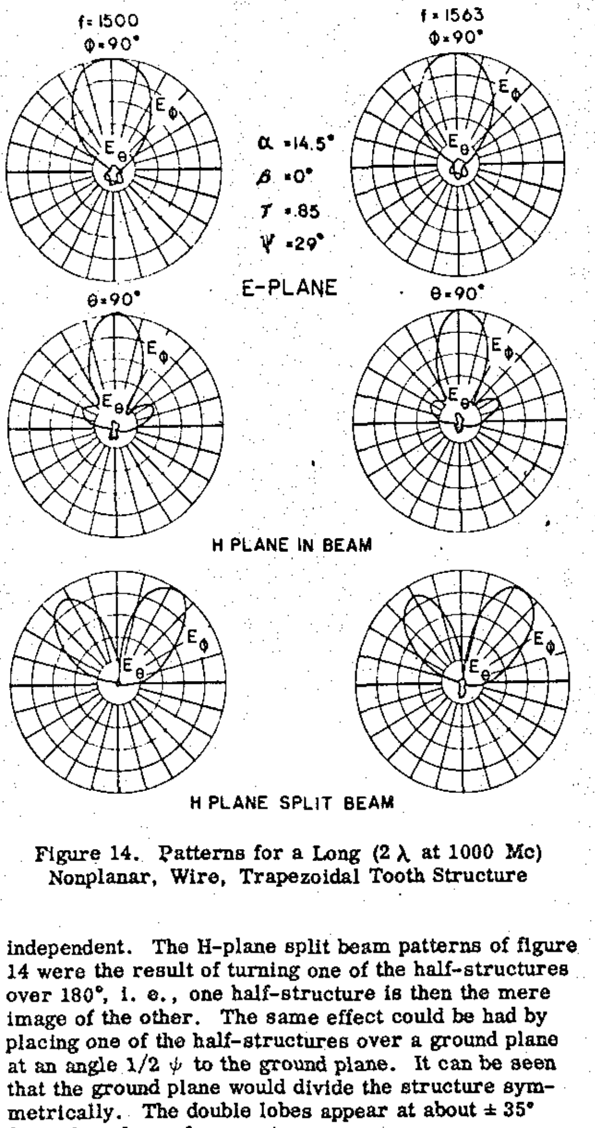


Figure 14. Patterns for a Long (2 λ at 1000 Mc) Nonplanar, Wire, Trapezoidal Tooth Structure

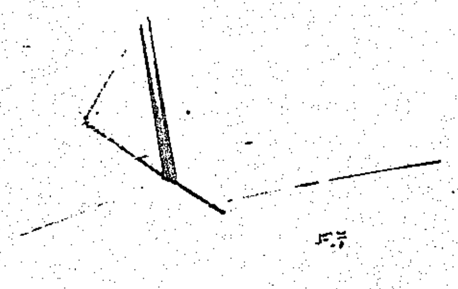


Figure 15. A Typical Wire, Nonplanar, Triangular Tooth Structure

independent. The H-plane split beam patterns of figure 14 were the result of turning one of the half-structures over 180°, i. e., one half-structure is then the mere image of the other. The same effect could be had by placing one of the half-structures over a ground plane at an angle 1/2 ψ to the ground plane. It can be seen that the ground plane would divide the structure symmetrically. The double lobes appear at about ± 35° from this plane of symmetry.

On the shorter structures, where the spacing between the half-structure and the ground plane was small, that is, much less than a half-wavelength, the effect of the ground plane caused the impedance to rotate around the center of a Smith chart in a periodic manner, but at a VSWR of five to eight, which is very undesirable. However, this long structure had impedance characteristics very similar to a structure in free space, with the Z_0 being only one-half the Z_0 of an antenna in free space. The actual Z_0 was 80 ohms with a VSWR of 1.1:1 over a period.

Wire Triangular Tooth Structures

Another step toward simplifying the construction of these logarithmically periodic structures was the triangular tooth or "Zig-Zag" structure illustrated in figure 15. It has the same parameters as the trapezoidal tooth structure of figure 10. Figure 16 shows typical patterns for this triangular tooth structure. In general, the pattern characteristics are a slight improvement over those of the trapezoidal tooth structure. The average E-plane beamwidth was 70° as compared to 67°; the average H-plane beamwidth was 89° as compared to 106°; and the front-to-back ratio was 14.4 db as compared to 14.9 db for the trapezoidal tooth structure. The impedance for the triangular tooth structure was slightly lower (100 ohms with a VSWR of 1.5 over the frequency range compared) than that of the trapezoidal tooth structure.

Another model of the triangular tooth structure was constructed similar to antenna 14 in table 3 (α = 45°, β = 0, τ = 0.707 and ψ = 45°). As before, the H-plane beamwidth was slightly narrower, the E-plane beamwidth was about the same, and the front-to-back ratio was slightly greater than that of the similar trapezoidal tooth structure.

Phase Rotation Principle

The phase rotation phenomenon is a basic characteristic of these logarithmically periodic structures and has been verified experimentally. It can best be explained in the following manner: if one of these structures is fed, and if the phase of the electric field received at a distant dipole (see figure 2) is measured relative to the phase of current at the feed point of the structure, the phase of the received signal will advance 360° as the structure is shrunk through a period. Or,

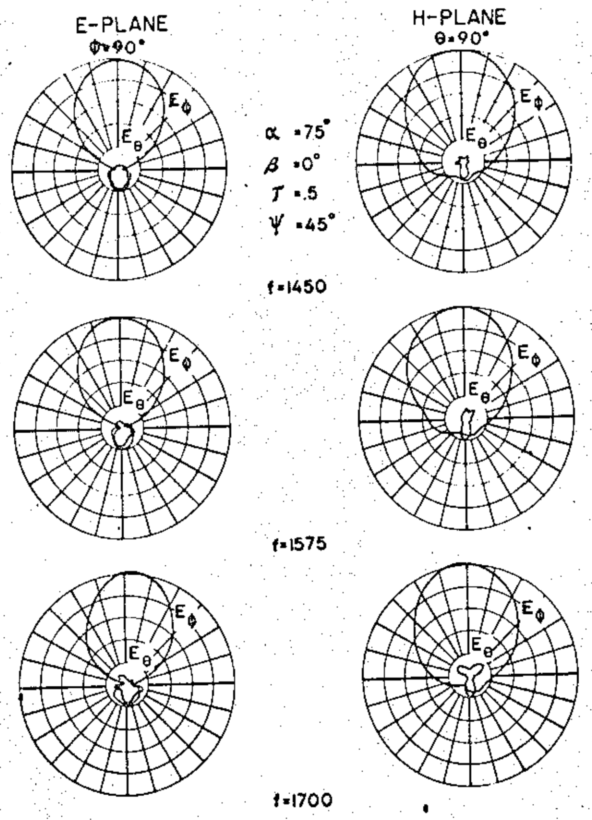


Figure 16. Patterns for Nonplanar, Wire, Triangular Tooth Structure

in other words, if the frequency of the exciting signal is increased by a period, and the phase is measured at the dipole while keeping the dipole at a constant electrical distance from the periodic structure, the phase will be delayed 360°, relative to the phase of the feed current. This characteristic is analagous to the pattern rotation principle[2] of angular structures.

This phenomenon is the factor which makes it possible to achieve the omnidirectional and circularly polarized logarithmically periodic structures discussed in the following sections.

Omnidirectional Structures

Often it is desirable to have a wide band antenna that gives omnidirectional patterns. The most common antenna to date that tends to meet such a requirement is the vertically polarized discone or biconical antenna. However, pattern breakup limits the bandwidth of these antennas to 2 or 3 to 1. The desirability of designing a logarithmically periodic structure with omnidirectional characteristics is readily apparent.

Since two dipoles arranged in a turnstile and fed ninety degrees out of phase give omnidirectional patterns it was decided to arrange two planar, sheet metal structures (which have approximate dipole patterns) in a turnstile as shown in figure 17a. Since the planar sheets were actually soldered together where they crossed, it is obvious that the two sheet structures could not be identical or the same result would occur as when feeding two crossed dipoles in phase (a bidirectional pattern with maximum lobes occurring at an angle of 45°). Therefore, one of the structures was made $\tau^{1/N}$ times the size of the other (where N is the number of arms of the structure) in order to obtain the 90° phasing.

An easy way to visualize such a structure is to imagine two cones placed apex to apex on a common

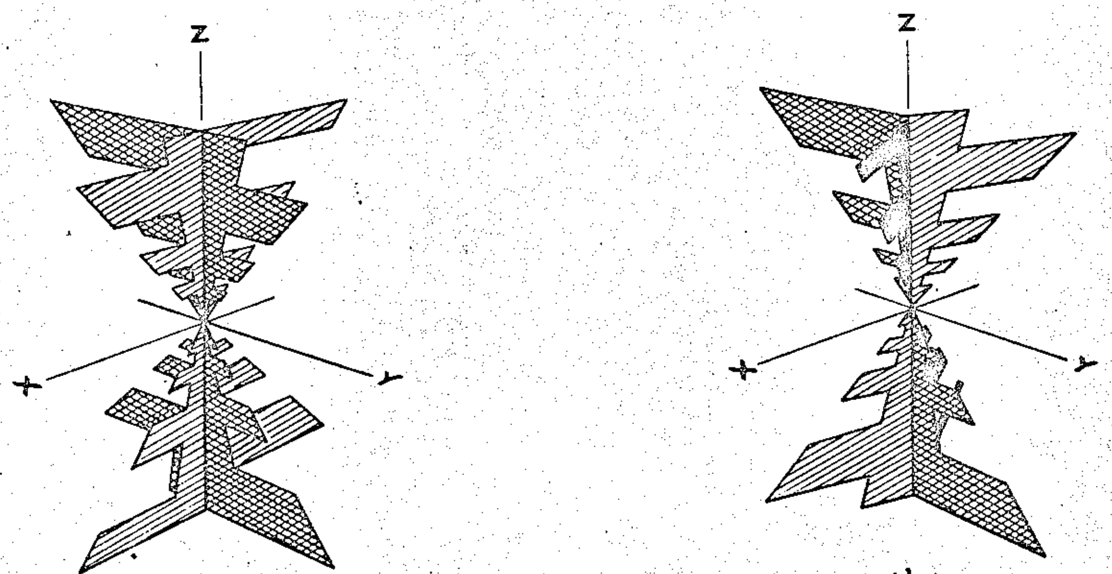


Figure 17. Types of Omnidirectional Structures

axis. Starting at the apex of each cone, an equiangular spiral is placed on the slant side of the cone with the axis of the spiral coinciding with the axis of the cone. The spiral on one cone is made to rotate clockwise; the spiral on the other cone is made to rotate counterclockwise as the two cones are viewed simultaneously from the point where their respective apexes meet. Actually, these spirals are the openings of grooves which become progressively wider and deeper as they spiral away from the apexes of the cones. The outlines of four arms of a four-arm structure would be the lines of intersection of the cones and two planes perpendicular to each other and intersecting on the axis of the cones. When the cone concept is used, it is possible to visualize a number of different structures. Figure 17b is an example of a structure with three arms.

Figure 18 is a photograph of a circular tooth structure constructed as stated above. The design ratio τ of this particular structure is 0.7. Of the various structures constructed and tested, it was found that the structure with a design ratio of 0.5 had the best pattern characteristics. Typical patterns of this structure are shown in figure 19. The $\theta = 90°$, ϕ variable patterns are omnidirectional within ±1.5 db over the frequency range of one period; the $\phi = 90°$, θ variable patterns are bidirectional and have an average beamwidth of about 65°. The characteristic impedance was 100 ohms with a normalized VSWR of 1.2 to 1.

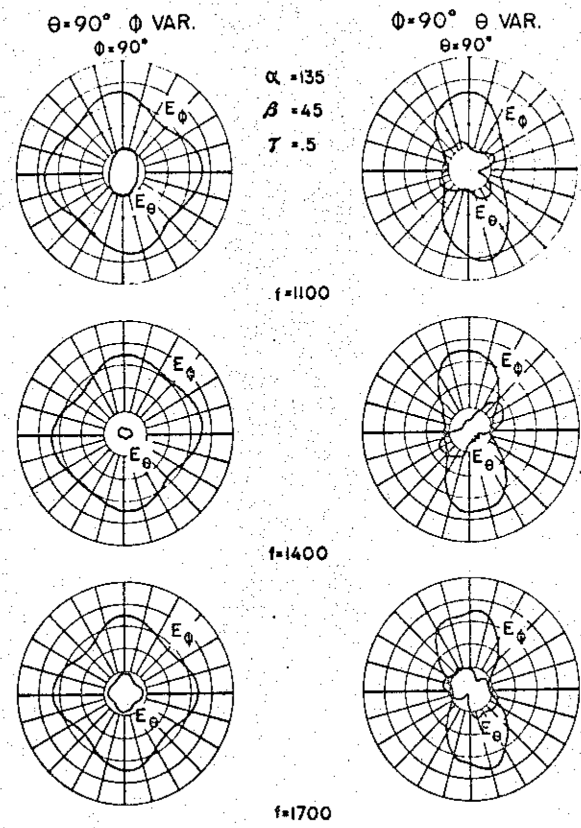


Figure 19. Patterns for Omnidirectional Curved Tooth Structure

Figure 18. A Typical, Four Armed, Sheet, Circular Tooth, Omnidirectional Structure

A limited investigation of the effect of varying the α angle while holding β fixed at 45° for a structure having a design ratio of 0.7 (figure 18) was made. As α was reduced from 135° to 115°, the E-plane patterns were unchanged while the H-plane beamwidth increased slightly from 68° to 75°. When α was reduced to 95°, the E-plane pattern was omnidirectional within ±3 db, and the H-plane pattern beamwidths were about 90°. The impedance did not change appreciably as α was reduced.

The trapezoidal tooth structure shown in figure 17a ($\alpha = 90°$, $\beta = 30°$, $\tau = 0.5$) did not have as uniform or as frequency independent omnidirectional characteristics as did the similar circular tooth structure. As a comparison, the trapezoidal tooth structure was omnidirectional within ±2.1 db as compared to ±1.5 db for the circular tooth structure; and the H-plane, bidirectional patterns were on an average 55° as compared to 65°. The impedance was 140 ohms and 100 ohms for the trapezoidal and circular tooth structures, respectively. Both had a normalized VSWR of 1.2 to 1.

The only other type of sheet metal omnidirectional structure tested was a three-armed circular tooth structure (see figure 17b for a similar trapezoidal tooth structure). The structure was omnidirectional within ±3 db and the patterns were more frequency dependent than the structure having four arms. It appears that the more arms a structure has (within reason), the more omnidirectional it will be.

One wire, trapezoidal tooth, omnidirectional structure was constructed and tested (see figure 20). The E-plane patterns varied somewhat in their omnidirectional characteristics with frequency, but on an average, they were omnidirectional within ±2.1 db; the H-plane patterns were bidirectional with an average beamwidth of 60°. The input impedance was 135 ohms with a normalized VSWR of 1.3 to 1. In view of the relative simplicity, this structure could be used as an hf antenna. The wire structure could be easily strung up between four wooden poles.

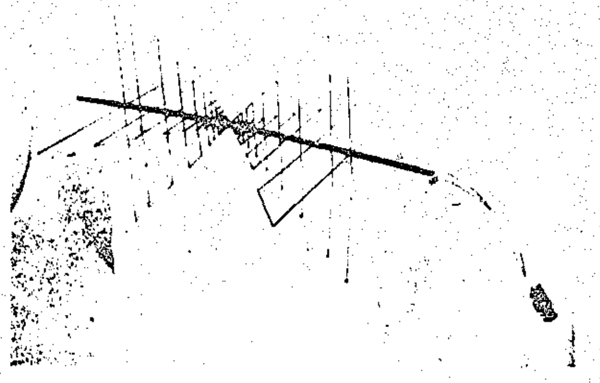


Figure 20. A Typical Four Armed, Wire, Trapezoidal Tooth, Omnidirectional Structure

Unfortunately, it is not possible to use one-half of any of the above structures over a ground plane (and fed against the ground plane) without having large variations of pattern and impedance over a period of frequency.

A limited investigation of circularly polarized, unidirectional logarithmically periodic broadband structures was performed. The most successful of the various techniques tried was that of taking the planar structure shown in figure 21 and placing the quarter-structures, one on each slant side of a pyramid. The angle between opposite slant sides of the pyramid is the ψ angle of the structure.

As can be observed from the figure, one structure is $\tau^{1/4}$ the size of the other. A very well-defined circularly polarized beam (at $\phi = 90°$, $\theta = 90°$) is obtained. The enlarged view of the feed point shows that, in general, two adjacent quarter-structures are fed against the remaining two quarter-structures; two and three are being fed against four and one. The sense of the circular polarization can be reversed by simply switching the feed point, or by feeding three and four against one and two.

Four experimental patterns over approximately a half-period are shown in figure 22. As can be seen, the axial ratio r as measured on the beam axis varied from 1.05 to 2 over this range. Since the patterns for the linearly polarized components (E_θ and E_ϕ) are very similar, it is expected that good circular polarization is obtained over most of the beam.

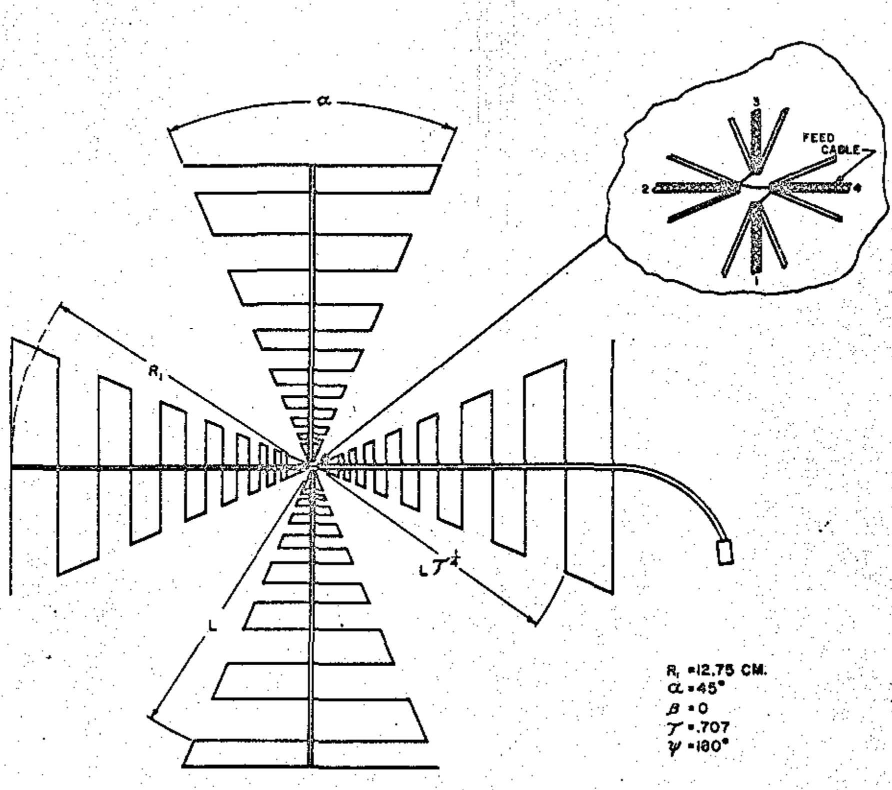


Figure 21. Wire, Trapezoidal Tooth, Circular Polarized Structure

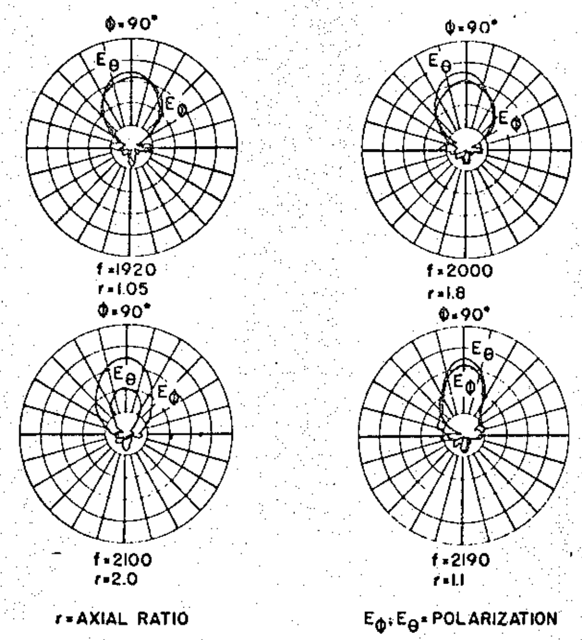


Figure 22. XY Plane Patterns of Circular Polarized Pyramidal Structure

Current Distribution Measurements

An attempt was made to measure the magnitude and phase of the currents flowing on the elements of a typical nonplanar, wire, trapezoidal tooth structure. The current distribution was very complex and the results were not too conclusive. However, it was observed that, as the magnitude of the currents was measured from the vertex out toward the longer transverse elements, a point of maximum current magnitude was reached. From this point, the magnitude of the current decreased to more than 30 db below its value at the maximum point. The transverse elements at this low current point were much longer than a half wavelength of the operating frequency. This tends to demonstrate that end effects are negligible on these structures, which must be the case for wide band operation. As would be expected, the point of maximum current magnitude shifted toward the vertex of the structure as the frequency was increased.

Conclusions

Many types of logarithmically periodic antenna structures have been built and tested. Most of those which gave essentially frequency independent operation have been reported here but there were many structures for which the pattern and/or impedance were quite frequency sensitive. Unfortunately, no theory has been established which even predicts the types of structures which will give frequency independent operation. The equicomplementary condition (for planar structures) is sufficient to insure frequency independent impedance but not patterns. All of the planar structures (even those that don't work) may be considered as cross sections of frequency independent three-dimensional angular structures so that this approach leads nowhere. Thus, it is felt that a theoretical investigation of this class of antennas would be most fruitful.

Nevertheless, a small amount of effort has led to the discovery of structures which give a wide variety of essentially frequency independent radiation characteristics over practically unlimited bandwidths. One of many possible applications is for flush-mounted microwave antennas. Here, unidirectional structures can be placed in cavities with the cavity having little influence on the electrical characteristics because of the unidirectional pattern.

Acknowledgment

Special thanks are due Dr. R. L. McCreary for his support and tolerance and to Forrest G. Arnold who constructed and tested many of the models.

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APPENDIX B.

LOGARITHMICALLY PERIODIC ANTENNA DESIGNS

R. H. DuHamel and F. R. Ore
Collins Radio Company
Cedar Rapids, Iowa

Summary

Research on new types of broadband logarithmically periodic antenna structures is reported. The antennas have pattern and impedance characteristics which are essentially independent of frequency over theoretically unlimited bandwidths. Bandwidths of ten to one are readily achieved in practice. Structures are described which provide linearly polarized omnidirectional, bidirectional and unidirectional patterns as well as circularly polarized bidirectional and unidirectional patterns.

Introduction

The subject of this paper is a class of antennas, called logarithmically periodic antenna structures, for which the pattern and impedance are essentially independent of frequency over theoretically unlimited bandwidths. Research on one particular type of these structures which provided a linearly polarized bidirectional beam was previously reported.[1] Since that time, various types of these structures have been discovered which provide linearly polarized unidirectional and omnidirectional patterns as well as circularly polarized unidirectional patterns. The proven versatility and wide bandwidth of these structures leads to the conclusion that the applications are practically unlimited. Obvious applications are to high-frequency and ECM antennas as well as to primary feeds for reflector and lens-type antennas.

The only other known class of frequency independent antennas is the angular antenna described by V. H. Rumsey.[2] Common examples are the discone, biconical, and bow-tie antennas which have bandwidths of approximately 2 or 3 to 1 for which the pattern is essentially independent of frequency. The so-called "end effect" limits the bandwidth of these antennas. An example of a recent type of angular antenna which apparently has negligible "end effect" is the equiangular or logarithmic spiral antenna[3] which has a frequency independent bandwidth of better than 10 to 1.

Referring to figure 1, the geometry of logarithmically periodic antenna structures is defined so that the pattern and impedance repeat periodically with the logarithm of the frequency. For planar structures, this is accomplished by defining their shape such that θ equals a periodic function of ln r where r and θ are the polar coordinates in the plane. Then if ln τ is the period of ln r, the operation of a structure of infinite extent would be the same for any two frequencies related by some integral power of τ. For the simple structure in figure 1a:

$$\tau = \frac{R_{N+1}}{R_N}$$

If the shape of the structure and the factor τ can be made such that the variation of the pattern and impedance over one period is small, then this will hold true for all periods, the result being an extremely broadband antenna. For finite structures, it has been found that since the end effect is negligible, wide bandwidths are readily obtained.

The two halves of the antenna are fed at the vertices either with a balanced two-wire line or with a coaxial line running up one half of the structure with the outer conductor bonded to the structure. For the structure of figure 1a, it is found that the lower and higher frequency limits are obtained when the longest and shortest teeth respectively are approximately 1/4 wavelength long. By probing the structure, it is found that the currents on the structure die off quite rapidly after progressing past the region where a tooth 1/4 wavelength long is positioned. This accounts for the negligible end effect. This antenna has a horizontally polarized bidirectional pattern with approximately equal and constant principal

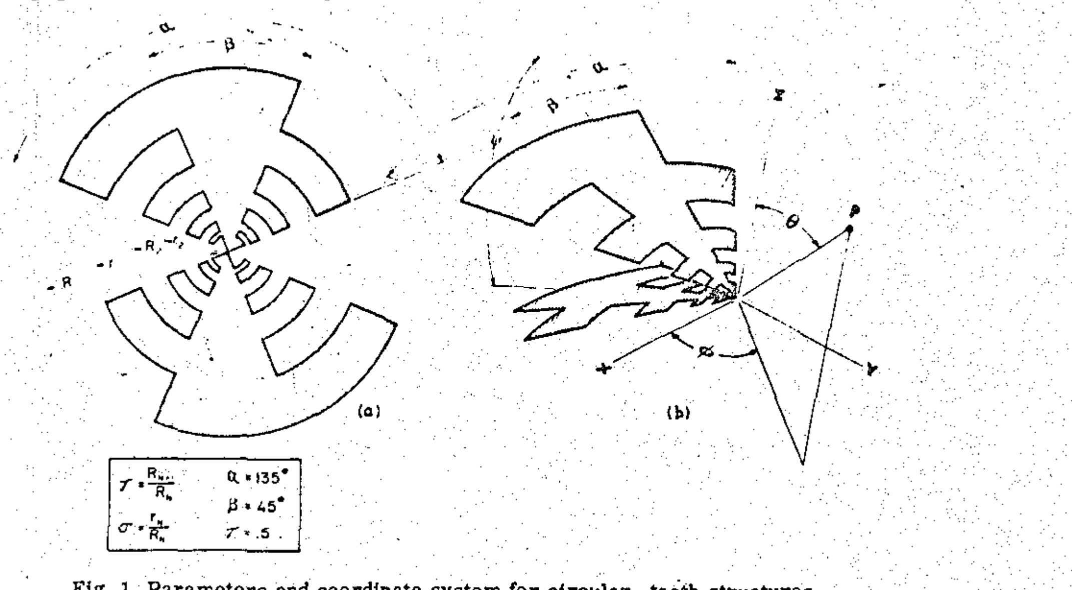

Fig. 1 Parameters and coordinate system for circular-tooth structures.

plane beamwidths over a frequency band of 10 to 1 or more and has a constant input impedance of approximately 170 ohms. The axes of the lobes are perpendicular to the plane of the structure. It was originally believed that it was necessary to make these structures identical to their complement in order to obtain a frequency independent input impedance. However, the results reported in this paper demonstrate that this equi-complementary condition is sufficient but not always necessary. Several frequency independent antennas will be introduced where the deviation from the equi-complementary condition is quite severe.

The fact that the electrical characteristics of logarithmically periodic structures repeat every period greatly simplifies the experimental investigation of them because it is only necessary to measure these characteristics over a half or single period in most cases. The operation over other periods may be readily predicted provided the end effect is negligible and that all dimensions are made proportional to their distance from the vertex.

As illustrated in figure 1b, D. E. Isbell[4] found that by bending the curved tooth structure about a horizontal axis, a unidirectional pattern pointing in the direction of the positive y axis could be obtained. Some control of the principal plane beamwidths and front-to-back ratio was obtained by varying the parameters α, β, ψ, and τ. Typical E-plane and H-plane beamwidths of 60° and 90° and a front-to-back ratio on the order of 10 to 15 db were obtained. It was found that the characteristic impedance of the structure decreased as the angle ψ was decreased, but that the VSWR referred to this characteristic impedance increased rather rapidly to 3.5:1 for $\psi = 30°$.

A great number of logarithmically periodic antenna configurations are possible. The investigation reported in this paper was conducted to study impedance, pattern, and polarization characteristics of a variety of structures. Another objective of the investigation was to devise practical forms of this type of antenna. Since large, circular tooth structures would be difficult to construct, the possibility of simplifying this basic structure by straightening the teeth and by making wire approximations of the teeth was investigated and is reported in the following sections.

Trapezoidal Tooth Sheet Structures

Figure 2 shows a sketch of a general trapezoidal tooth structure and gives a definition of the coordinate system and various parameters that will be used throughout this paper to describe the various structures. Figure 3 is a photograph of a printed circuit board form of this type of structure which was used for the experimental investigation. By comparing a structure cut from sheet metal in a conventional way to an identical structure etched on teflon dielectric printed circuit

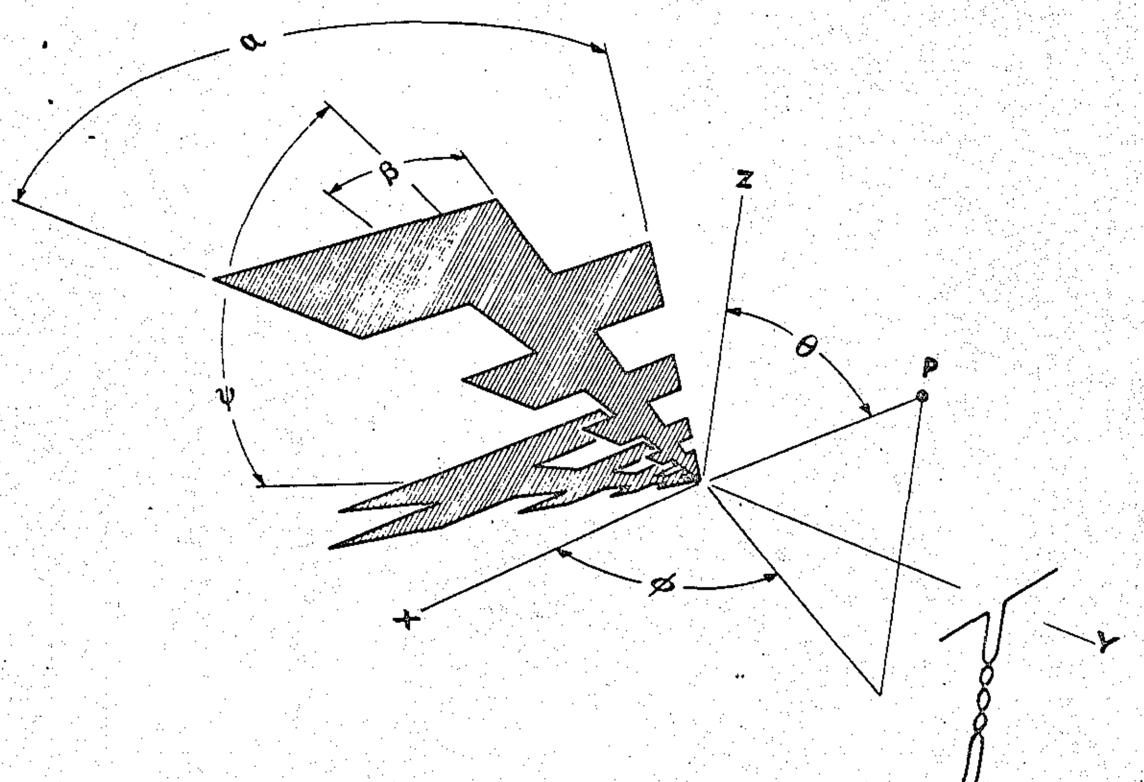

Fig. 2 Parameter and coordinate system for trapezoidal-tooth structures.

Fig. 3

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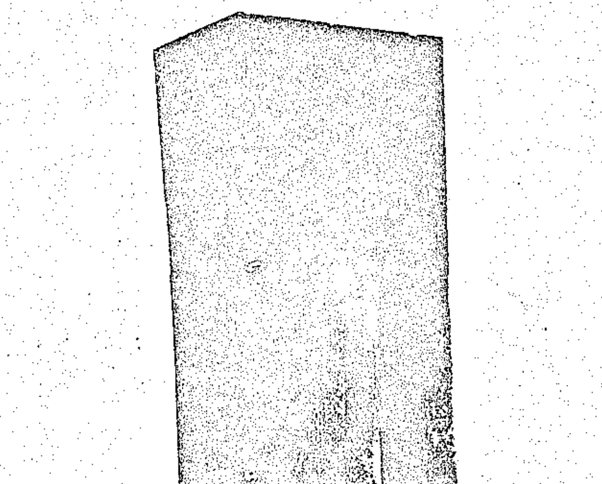


Fig. 3 A printed, nonplanar, trapezoidal-tooth structure bent about the X axis.

board, it was found that the printed circuit board models could be used up to about 3000 mc without the presence of the dielectric becoming too objectionable. As a point of interest, the undesired metal can be removed either by an etching process or by cutting around the outline of the structure with a sharp instrument and then peeling the metal away. Two models of planar structures (with $\psi = 180°$) were constructed with the following parameters: $\alpha = 90°$, $\beta = 30°$ for one and

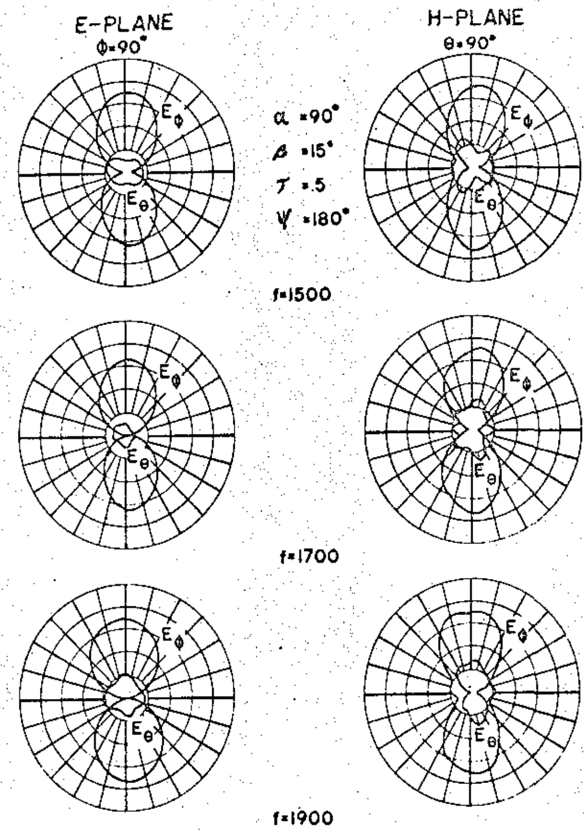


Fig. 4 Patterns for planar trapezoidal-tooth structure.

$\beta = 15°$ for the other, $\tau = 0.5$, and R_1, the perpendicular distance from the vertex of one-half the structure to the longest element, is 12.75 cm. Patterns were taken over about a two to one frequency range (900 to 2100 mc). Figure 4 shows typical patterns for this type of structure. In general, both structures gave essentially frequency independent, linearly polarized, bidirectional patterns. Over the frequency range stated above, the E-plane (pattern in the xy plane of figure 1b) half-power beamwidth varied from 65° to 80° with an average beamwidth of 71°, and the H-plane (pattern in the yz plane of figure 1b) half-power beamwidth varied from 60° to 69° with an average beamwidth of 62°. Of the two antennas tested, the one having the narrower center section ($\beta = 15°$) demonstrated slightly less variation of beamwidth with frequency.

Patterns were taken for a nonplanar structure with $\psi = 60°$ over a 5:1 frequency range. Typical patterns are shown in figure 5. The E-plane patterns were unidirectional with beamwidths that varied from 60° to 75° with an average beamwidth of 65° and the H-plane patterns had beamwidths that varied from 80° to 110° with an average beamwidth of 85°. The front-to-back ratio, due to the cross polarization E_θ, had an average value of about 9 db; the front-to-back ratio, due to the major polarization E_ϕ, had an average value of about 13 db.

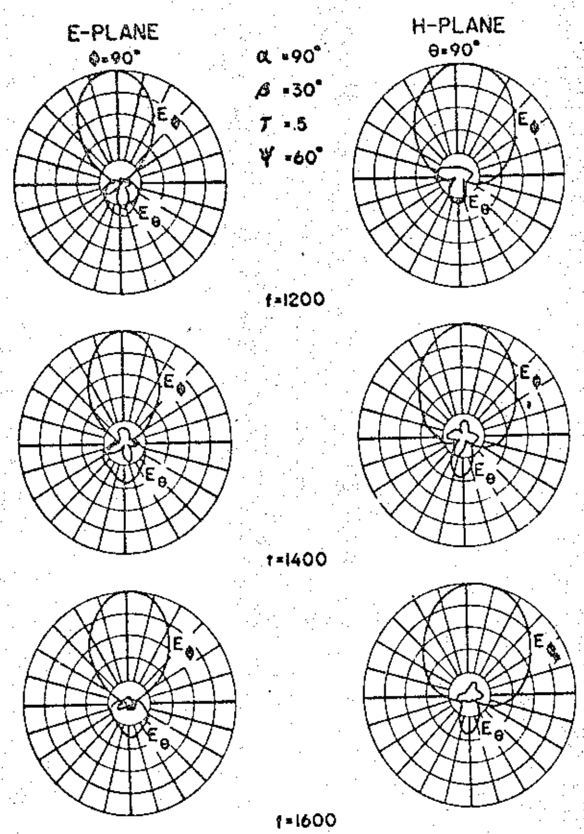


Fig. 5 Patterns for nonplanar (bent about horizontal axis) trapezoidal - tooth structure.

TABLE 1: VARIATION OF Z_0 AND VSWR WITH ψ ANGLE FOR A PRINTED, TRAPEZOIDAL TOOTH STRUCTURE

ψ Angle	Z_0	VSWR (Referred to Z_0)
180	170	1.4
60	105	1.6

Table 1 shows how the impedance of this particular structure compared with the corresponding planar structure. The input impedance Z_0 was reduced from 170 ohms to about 105 ohms and the VSWR's referred to their respective input impedances were about the same. Thus, the impedance characteristic of a nonplanar trapezoidal tooth structure is considerably better than that of a curved tooth structure.

Another possible nonplanar structure is where the original planar structure is bent about its vertical axis to an included acute angle χ. A structure of this type is shown in figure 6. Patterns and impedance were measured for a variation in χ from 180° to 60° in 30° steps. It was found that the E-plane patterns showed a definite tendency toward varying from bidirectional at $\chi = 180°$ to omnidirectional at $\chi = 60°$; the H-plane patterns remained bidirectional over the same range.

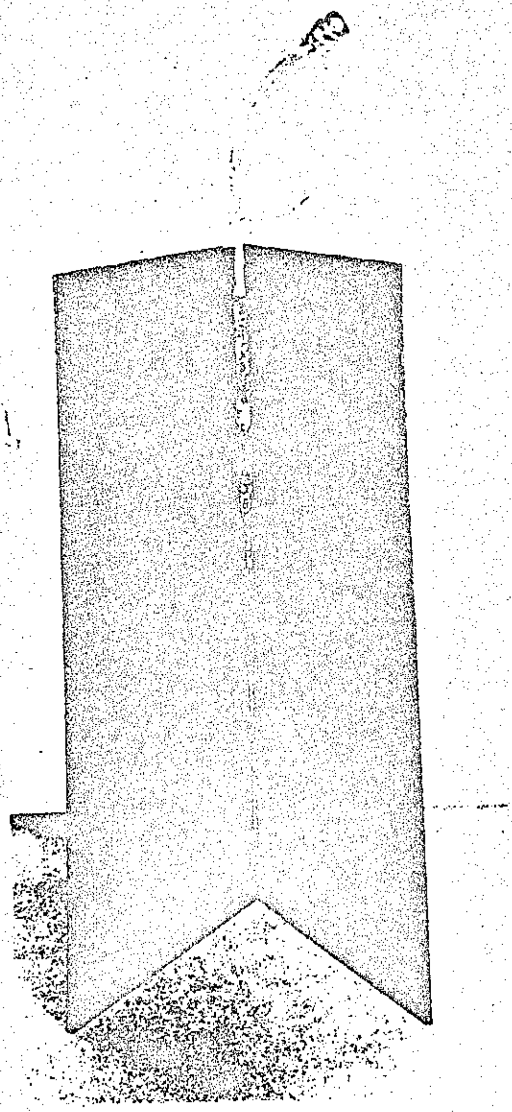


Fig. 6 A printed, nonplanar, trapezoidal - tooth structure bent about the Z axis.

Typical patterns for $\chi = 90°$ are shown in figure 7. In general, the patterns varied considerably with frequency.

TABLE 2: VARIATION OF Z_0 AND VSWR WITH VARIOUS χ ANGLES FOR A PRINTED, TRAPEZOIDAL TOOTH STRUCTURE

χ Angle	Z_0	VSWR (Referred to Z_0)
180	170	1.4
120	180	1.35
90	200	1.4
60	210	1.9

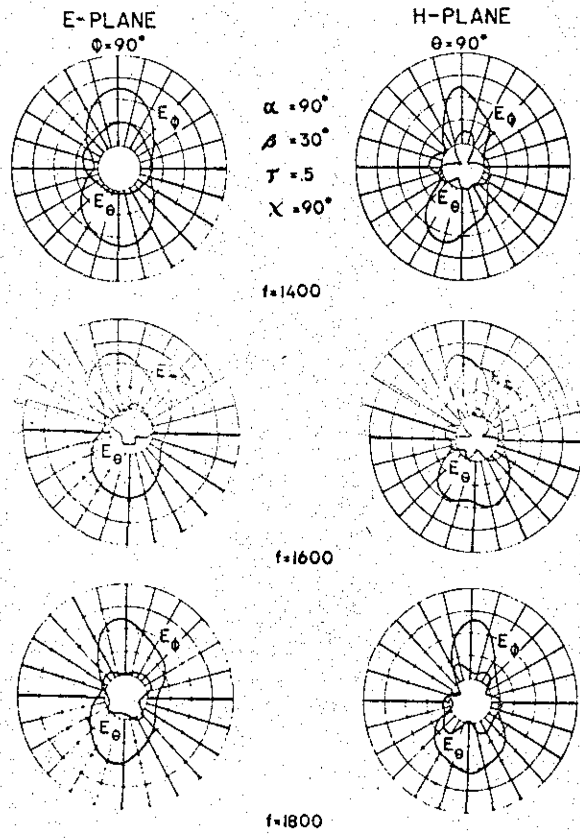
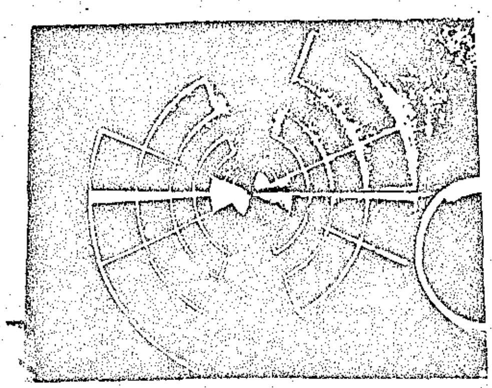
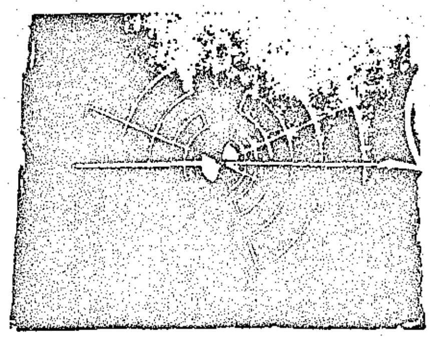


Fig. 7 Patterns for nonplanar (bent about vertical axis) trapezoidal - tooth structure.



(a) With Tapered Elements



(b) With Uniform Elements

Fig. 8 Planar, printed, wire - like, circular - tooth structure.

The variation of impedance with the angle χ was rather interesting, as can be seen in table 2. The average input impedance Z_0 increased as the χ angle was decreased. This was just the reverse of the effect that the reduction in . produced.

Wire Structures

Wire, Curved Tooth, Planar Structure

The approximation of sheet structures with wire structures was first investigated for a circular tooth structure. Two different approximations are shown in figure 8 and as can be seen, all the metal was removed except for narrow strips outlining the teeth. A still closer observation will indicate that the horizontal metal strips in figure 8a vary in width proportional to the distance from the center of the structure and the vertical members are triangular in shape. This is necessary in order to make the structure logarithmically periodic. Figure 8b is a structure identical to that of figure 8a, except that all members are of uniform width.

The average input impedance of the structure in figure 8b was slightly lower than that in figure 8a, 110 ohms for figure 8b as compared to 150 ohms for figure 8a. As an interesting comparison, the impedance of a similar basic circular tooth structure was about 150 ohms.

In general, the patterns for the two cases were very similar. In both cases, the patterns were essentially independent of frequency, with the structure having tapered elements being slightly less frequency sensitive. The beamwidths in both the above cases were slightly wider than the beamwidth of the corresponding basic circular tooth structure.

Nonplanar, Wire, Trapezoidal Tooth Structure

Since the circular tooth structures with only the outline of the teeth being made of metal performed almost as well as the basic circular tooth structure, this technique was used in constructing the trapezoidal tooth structures. In figures 9a and 9b are two typical types of wire, nonplanar, trapezoidal tooth structures. The only difference is that in figure 9a, the β angle has

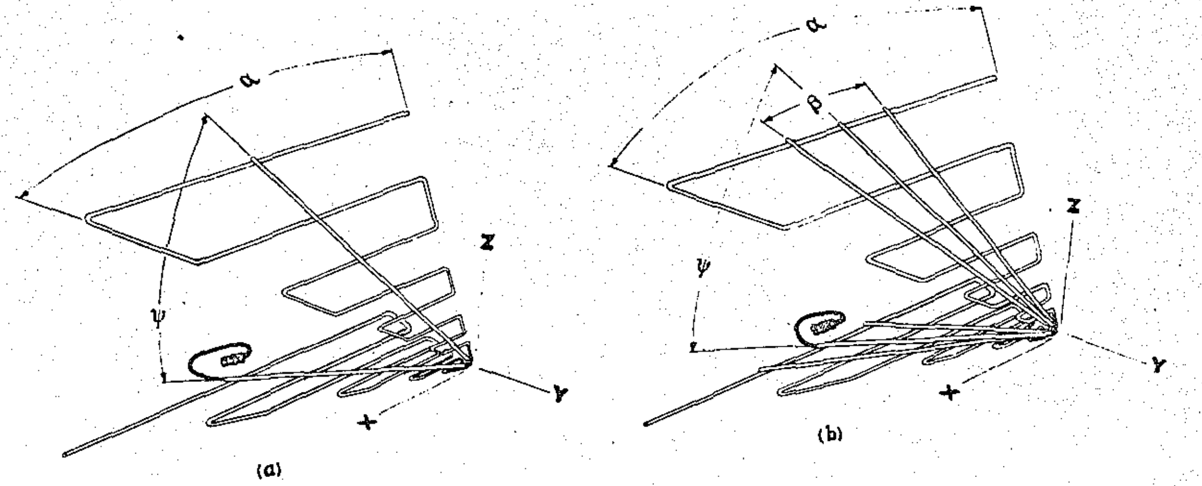


Fig. 9 Types of nonplanar, wire, trapezoidal-tooth structures.

been decreased to zero. Figure 10 is a photograph of a typical model used in the investigation of this type of structure. (In the photograph, the dielectric rod between the halves of the antenna was used for support only and is not part of the antenna.)

A considerable number of models of this type of structure with various values of the parameters α, ψ, and τ were constructed and tested. In general, the patterns of these structures were quite independent of frequency, especially those with the larger values of τ. Variations of the beamwidth of only several percent over a period of operation were common.

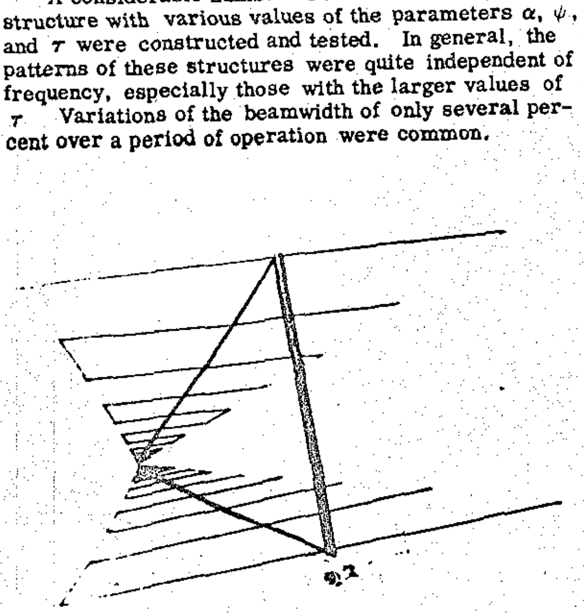


Fig. 10 A typical, wire, nonplanar, trapezoidal-tooth structure.

Figure 11 shows the patterns over a half-period for the antenna shown in figure 10. This particular antenna had an average E-plane beamwidth of 67°, an average H-plane beamwidth of 106° and an average front-to-back ratio of 15 db.

Table 3 shows how the beamwidth, gain, and front-to-back ratio are functions of the parameters of the antenna for several structures. From the table, it can be seen that both E-plane and H-plane beamwidths decrease as the design ratio of τ is increased. For example, take $\psi = 45°$, $\alpha = 60°$; then as τ was varied from 0.4 to 0.707, the E-plane beamwidth decreased from 86° to 64°, and the H-plane beamwidth decreased from 112° to 79°. It can then be concluded that if high gain is required, a large design ratio is desirable. It was found that the spacing between two adjacent transverse elements should not be greater than 0.3 of the length of the longer element. Otherwise, the pattern starts breaking up. Also, from the table it can be seen that the H-plane beamwidth increased with a decrease in ψ angle for any one design ratio, while the E-plane pattern is essentially independent of the ψ angle. Also, the front-to-back ratio, in general, increased with a decrease in ψ angle. The α angle had a second-order effect on the beamwidth; with an increase in α, a decrease in E-plane beamwidth and an increase in H-plane beamwidth resulted.

In using the information in table 3 to design an antenna with relatively high gain, high front-to-back ratio, not too great complexity (the number of elements increases as the design ratio increases), one must make a compromise as to what parameters to choose. For example, antenna number 14 has $\alpha = 60°$, $\beta = 0$, $\psi = 45°$, and $\tau = 0.6$. The gain is 6.5 db over a dipole and the front-to-back ratio is 15.8 db.

These pattern characteristics compare very favorably with those of a three-element Yagi antenna. Admittedly, this type of structure is somewhat more complex to construct than a Yagi, insofar as the number of elements required is greater, and it is necessary to use either a tapered coax line or a balanced open wire transmission line transformer in order to match the impedance of the structure to conventional transmission lines. It has, however, the added advantage of having

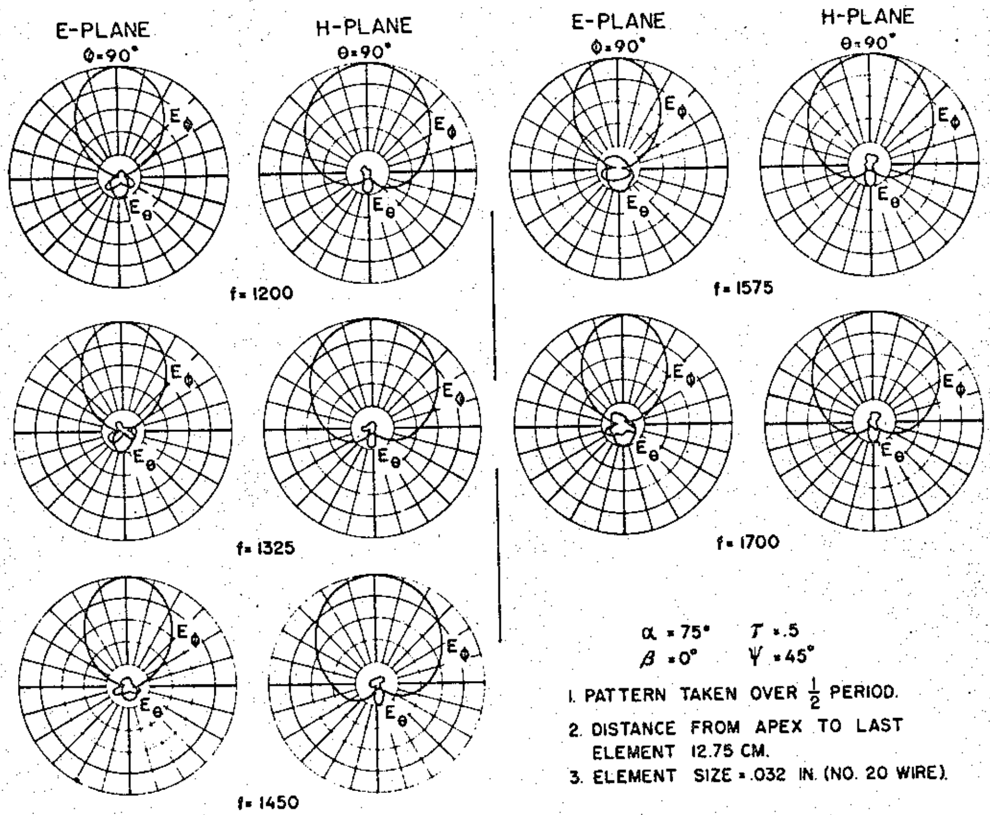


Fig. 11 Patterns for a typical, wire, nonplanar, trapezoidal-tooth structure.

TABLE 3. PATTERN CHARACTERISTICS FOR VARIOUS WIRE, TRAPEZOIDAL TOOTH STRUCTURES

	PARAMETERS			AVE. HALF POWER BEAM WIDTHS IN DB			MAX.
ANT	α	τ	ψ	E PLANE	H PLANE	APPROX. GAIN/DIPOLE IN DB	SIDE LOBE LEVELS IN DB
1	75	.4	30	74	155	3.5	12.4
2	75	.4	45	72	125	4.5	11.4
3	75	.4	60	73	103	5.3	8.6
4	60	.4	30	85	153	3.0	12.0
5	60	.4	45	86	112	4.2	8.6
6	60	.4	60	87	87	5.3	7.0
8	75	.5	30	66	126	4.9	17.0
9	75	.5	45	67	106	5.6	14.9
10	75	.5	60	68	93	6.1	12.75
11	60	.5	30	70	118	4.9	17.7
12	60	.5	45	71	95	5.8	14.0
13	60	.5	60	71	77	6.7	9.9
14	60	.6	45	67	85	6.5	15.8
15	60	.707	45	64	79	7.0	15.8
16	45	.707	45	66	66	7.7	12.3

essentially frequency independent impedance and pattern characteristics over a ten to one or more bandwidth.

The patterns of a larger antenna model, with the above design parameters (see figure 12) were measured over a ten to one frequency range (100 to 1000 mc). A slight increase in the beamwidths and a slight decrease in the front-to-back ratio was observed at about 300 mc. This effect was investigated by taking patterns of the structure and removing the elements one by one. It was found that the elements whose lengths were about 1.5 λ were responsible for these pattern changes. Thus, some end effect was noticeable for this structure at a frequency approximately three times the low frequency limit of the antenna.

TABLE 4. VARIATION OF AVERAGE IMPEDANCE AND VSWR WITH ψ ANGLE FOR A TYPICAL, WIRE, TRAPEZOIDAL TOOTH STRUCTURE

ψ Angle	Zo	VSWR (Referred to Z_0)
60	120	1.4
45	110	1.45
30	105	1.5
7	65	1.8

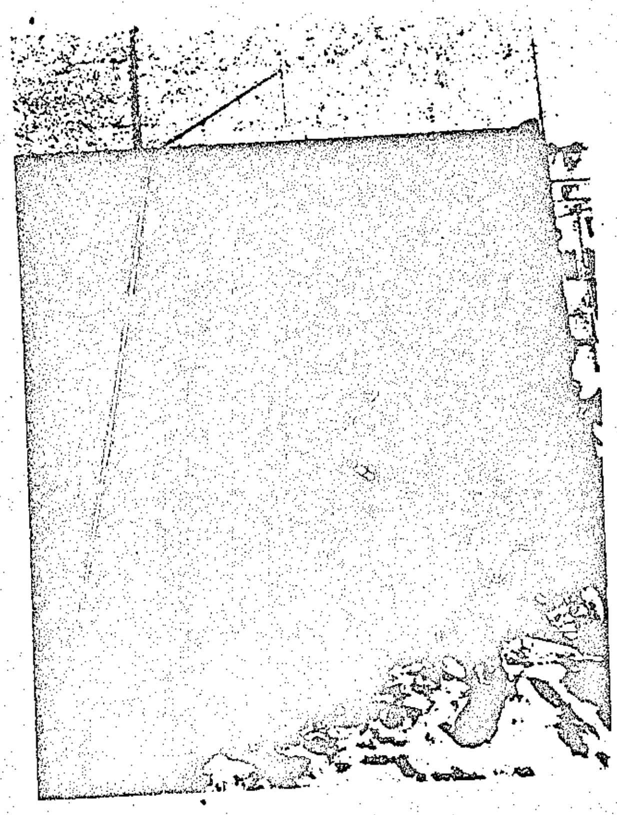


Fig. 12 A larger model of a (low-frequency limit of about 100 mc) wire, nonplanar, trapezoidal-tooth structure.

Table 4 shows how the impedance varies with the ψ angle for a typical wire, trapezoidal tooth structure.

The impedance of the wire, trapezoidal tooth structure (shown in figure 10) having the following parameters: $\alpha = 75°$, $\beta = 0$, $\tau = 0.5$, $\psi = 45°$, and $R_1 = 12.75$ inches, was measured over a sixteen to one frequency band (250 to 4000 mc). The impedance was good from 350 mc to 4000 mc or an eleven to one frequency band. This closely agrees with the previous definition of the low frequency limit since the width of the structure at the last element was 19.5 inches or a half wavelength at 304 mc. The actual measurements showed that the input impedance Z_0 decreased slowly and uniformly from about 150 ohms at 350 mc to about 75 ohms at the high end of the range of measurements. This change in input impedance is due to the modeling technique rather than a fault of the antenna. The elements of this particular model were of constant diameter (# 14 wire) and as the frequency was increased, the length-to-diameter ratio of the elements which were responsible for the radiation decreased. As further proof that modeling was partially responsible for this Z_0 change, the impedance of another larger model, figure 12, where the elements had been slightly tapered, was measured over a ten to one frequency range. Although the Z_0 of this structure also decreased as the frequency increased, the change was somewhat smaller. Thus, in order to obtain good frequency independence over a 10:1 bandwidth, it is necessary to model the structure accurately according to the design principles.

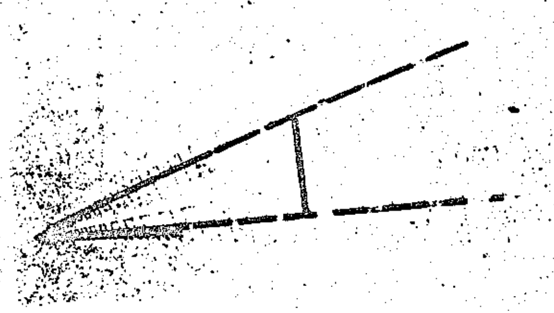


Fig. 13 A long (2λ at 1,000 mc) nonplanar, wire, trapezoidal-tooth structure.

From the observed trends indicated in table 3, an antenna with relatively high gain was designed. The model was constructed as shown in figure 13. The parameters for this particular model were $\alpha = 14.5°$, $\beta = 0$, $\tau = 0.85$, $\psi = 29°$ and $R_1 = 60$ cm. In order to make the vertical spacing between horizontal elements of the same length of the two half-structures about twice the length of the particular elements, ψ was set equal to 29°. R_1 was chosen equal to 60 cm in order to make the last element one half-wavelength long at 1000 mc. The patterns for this structure are shown in figure 14. The average E-plane beamwidth was 59°; the average H-plane beamwidth was 38°; and the front-to-back ratio was about 18 db. The resulting gain of this antenna then was slightly better than 10 db over a dipole, and the patterns were extremely frequency

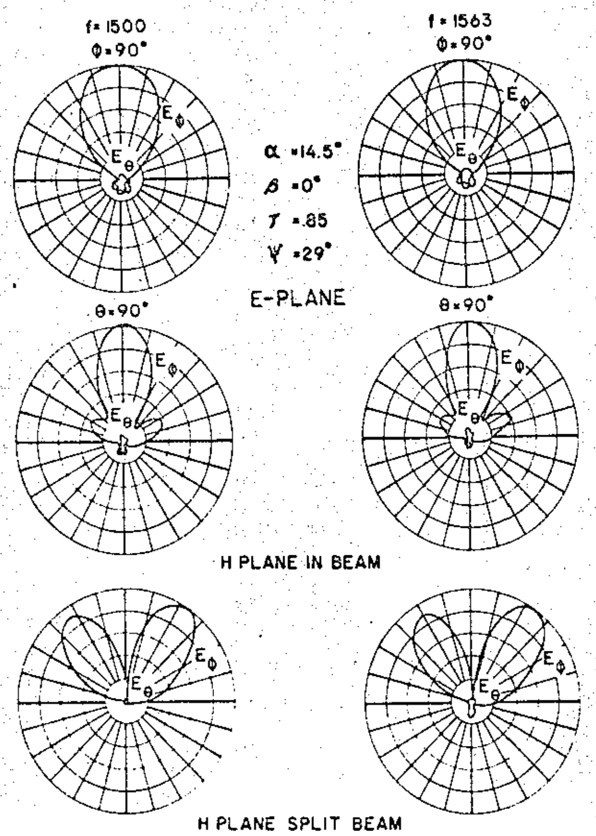


Fig. 14 Patterns for a long (2 λ at 1,000 mc) nonplanar, wire, trapezoidal-tooth structure.

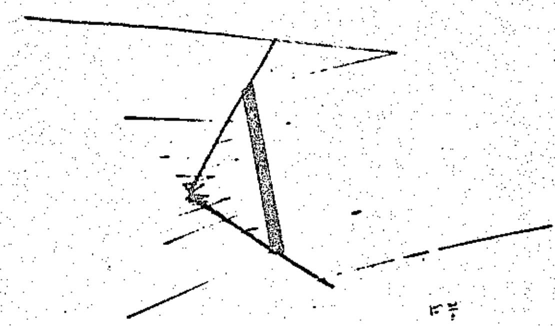


Fig. 15 A typical, wire, nonplanar, triangular-tooth structure.

independent. The H-plane split beam patterns of figure 14 were the result of turning one of the half-structures over 180°, i. e., one half-structure is then the mere image of the other. The same effect could be had by placing one of the half-structures over a ground plane at an angle 1/2 ψ to the ground plane. It can be seen that the ground plane would divide the structure symmetrically. The double lobes appear at about ± 35° from this plane of symmetry.

On the shorter structures, where the spacing between the half-structure and the ground plane was small, that is, much less than a half-wavelength, the effect of the ground plane caused the impedance to rotate around the center of a Smith chart in a periodic manner, but at a VSWR of five to eight, which is very undesirable. However, this long structure had impedance characteristics very similar to a structure in free space, with the Z_0 being only one-half the Z_0 of an antenna in free space. The actual Z_0 was 80 ohms with a VSWR of 1.1:1 over a period.

Wire Triangular Tooth Structures

Another step toward simplifying the construction of these logarithmically periodic structures was the triangular tooth or "Zig-Zag" structure illustrated in figure 15. It has the same parameters as the trapezoidal tooth structure of figure 10. Figure 16 shows typical patterns for this triangular tooth structure. In general, the pattern characteristics are a slight improvement over those of the trapezoidal tooth structure. The average E-plane beamwidth was 70° as compared to 67°; the average H-plane beamwidth was 89° as compared to 106°; and the front-to-back ratio was 14.4 db as compared to 14.9 db for the trapezoidal tooth structure. The impedance for the triangular tooth structure was slightly lower (100 ohms with a VSWR of 1.5 over the frequency range compared) than that of the trapezoidal tooth structure.

Another model of the triangular tooth structure was constructed similar to antenna 14 in table 3 (α = 45°, β = 0, τ = 0.707 and ψ = 45°). As before, the H-plane beamwidth was slightly narrower, the E-plane beamwidth was about the same, and the front-to-back ratio was slightly greater than that of the similar trapezoidal tooth structure.

Phase Rotation Principle

The phase rotation phenomenon is a basic characteristic of these logarithmically periodic structures and has been verified experimentally. It can best be explained in the following manner: if one of these structures is fed, and if the phase of the electric field received at a distant dipole (see figure 2) is measured relative to the phase of current at the feed point of the structure, the phase of the received signal will advance 360° as the structure is shrunk through a period. Or,

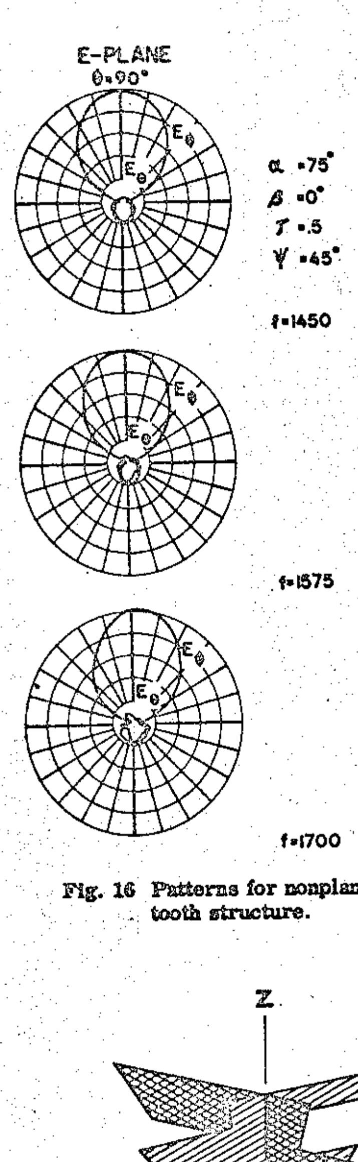


Fig. 16 Patterns for nonplanar, wire, triangular-tooth structure.

In other words, if the frequency of the exciting signal is increased by a period, and the phase is measured at the dipole while keeping the dipole at a constant electrical distance from the periodic structure, the phase will be delayed 360°, relative to the phase of the feed current. This characteristic is analagous to the pattern rotation principle[2] of angular structures.

This phenomenon is the factor which makes it possible to achieve the omnidirectional and circularly polarized logarithmically periodic structures discussed in the following sections.

Omnidirectional Structures

Often it is desirable to have a wide band antenna that gives omnidirectional patterns. The most common antenna to date that tends to meet such a requirement is the vertically polarized discone or biconical antenna. However, pattern breakup limits the bandwidth of these antennas to 2 or 3 to 1. The desirability of designing a logarithmically periodic structure with omnidirectional characteristics is readily apparent.

Since two dipoles arranged in a turnstile and fed ninety degrees out of phase give omnidirectional patterns, it was decided to arrange two planar, sheet metal structures (which have approximate dipole patterns) in a turnstile as shown in figure 17a. Since the planar sheets were actually soldered together where they crossed, it is obvious that the two sheet structures could not be identical or the same result would occur as when feeding two crossed dipoles in phase (a bidirectional pattern with maximum lobes occurring at an angle of 45°). Therefore, one of the structures was made $\tau^{1/N}$ times the size of the other (where N is the number of arms of the structure) in order to obtain the 90° phasing.

An easy way to visualize such a structure is to imagine two cones placed apex to apex on a common

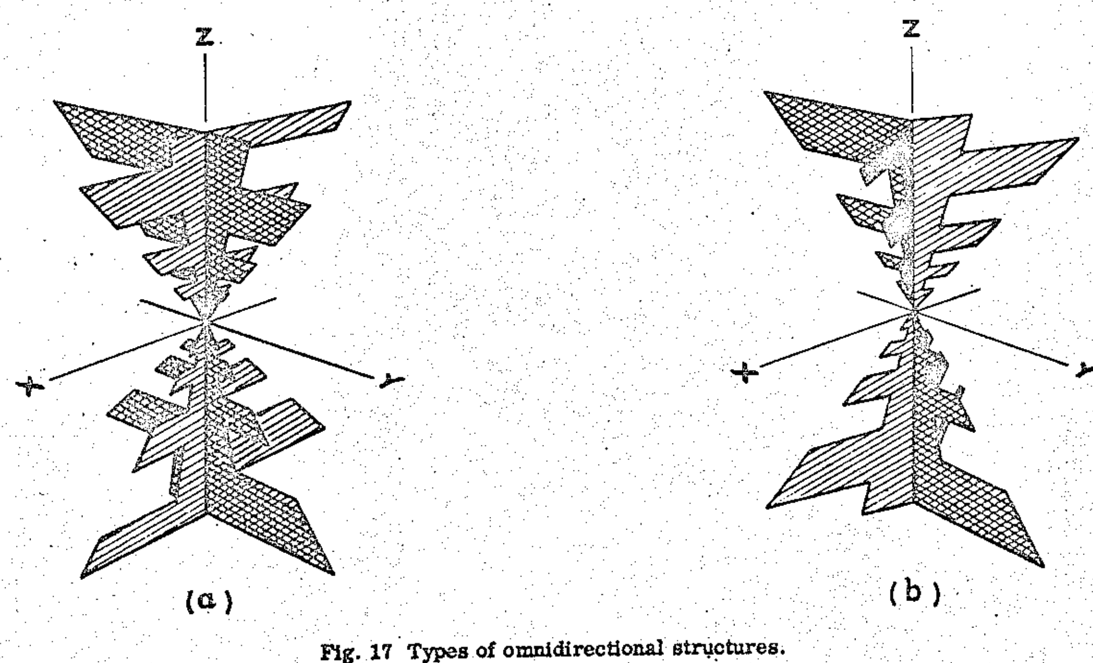


Fig. 17 Types of omnidirectional structures.

axis. Starting at the apex of each cone, an equiangular spiral is placed on the slant side of the cone with the axis of the spiral coinciding with the axis of the cone. The spiral on one cone is made to rotate clockwise; the spiral on the other cone is made to rotate counterclockwise as the two cones are viewed simultaneously from the point where their respective apexes meet. Actually, these spirals are the openings of grooves which become progressively wider and deeper as they spiral away from the apexes of the cones. The outlines of four arms of a four-arm structure would be the lines of intersection of the cones and two planes perpendicular to each other and intersecting on the axis of the cones. When the cone concept is used, it is possible to visualize a number of different structures. Figure 17b is an example of a structure with three arms.

Figure 18 is a photograph of a circular tooth structure constructed as stated above. The design ratio τ of this particular structure is 0.7. Of the various structures constructed and tested, it was found that the structure with a design ratio of 0.5 had the best pattern characteristics. Typical patterns of this structure are shown in figure 19. The $\theta = 90°$, ϕ variable patterns are omnidirectional within ±1.5 db over the frequency range of one period; the $\phi = 90°$, θ variable patterns are bidirectional and have an average beamwidth of about 65°. The characteristic impedance was 100 ohms with a normalized VSWR of 1.2 to 1.

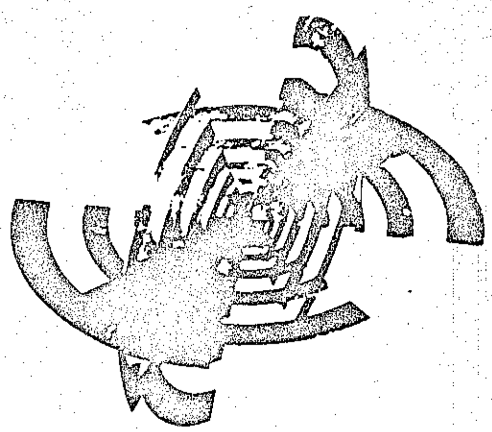


Fig. 18 A typical, four-armed, sheet, circular-tooth, omnidirectional structure.

A limited investigation of the effect of varying the α angle while holding β fixed at 45° for a structure having a design ratio of 0.7 (figure 18) was made. As α was reduced from 135° to 115°, the E-plane patterns were unchanged while the H-plane beamwidth increased slightly from 68° to 75°. When α was reduced to 95°, the E-plane pattern was omnidirectional within ±3 db, and the H-plane pattern beamwidths were about 90°. The impedance did not change appreciably as α was reduced.

The trapezoidal tooth structure shown in figure 17a ($\alpha = 90°$, $\beta = 30°$, $\tau = 0.5$) did not have as uniform

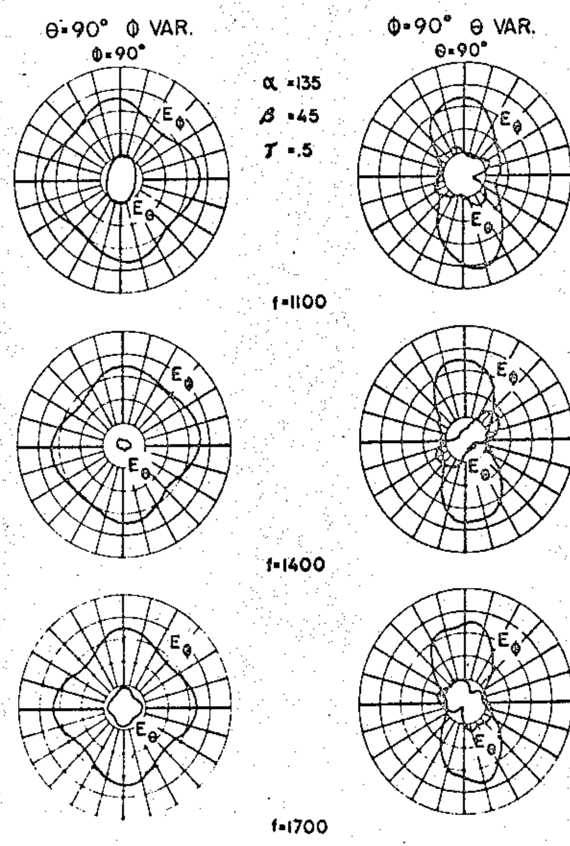


Fig. 19 Patterns for omnidirectional curved-tooth structure.

or as frequency independent omnidirectional characteristics as did the similar circular tooth structure. As a comparison, the trapezoidal tooth structure was omnidirectional within ±2.1 db as compared to ±1.5 db for the circular tooth structure; and the H-plane, bidirectional patterns were on an average 55° as compared to 65°. The impedance was 140 ohms and 100 ohms for the trapezoidal and circular tooth structures, respectively. Both had a normalized VSWR of 1.2 to 1.

The only other type of sheet metal omnidirectional structure tested was a three-armed circular tooth structure (see figure 17b for a similar trapezoidal tooth structure). The structure was omnidirectional within ±3 db and the patterns were more frequency dependent than the structure having four arms. It appears that the more arms a structure has (within reason), the more omnidirectional it will be.

One wire, trapezoidal tooth, omnidirectional structure was constructed and tested (see figure 20). The E-plane patterns varied somewhat in their omnidirectional characteristics with frequency, but on an average, they were omnidirectional within ±2.1 db; the H-plane patterns were bidirectional with an average beamwidth of 60°. The input impedance was 135 ohms with a normalized VSWR of 1.3 to 1. In view of the relative simplicity, this structure could be used as an hf antenna. The wire structure could be easily strung up between four wooden poles.

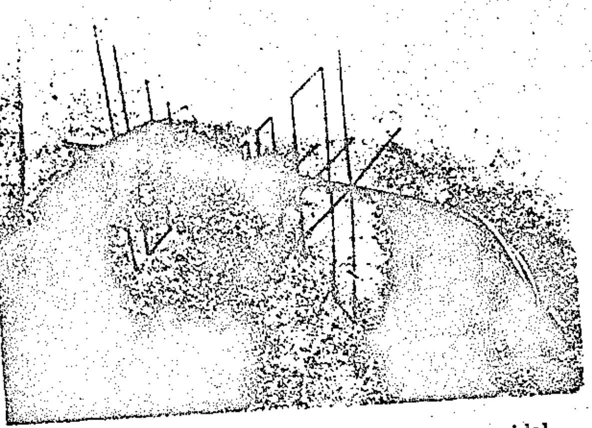


Fig. 20 A typical, four-armed, wire, trapezoidal-tooth, omnidirectional structure.

Unfortunately, it is not possible to use one-half of any of the above structures over a ground plane (and fed against the ground plane) without having large variations of pattern and impedance over a period of frequency.

Circularly Polarized Antennas

A limited investigation of circularly polarized, unidirectional logarithmically periodic broadband structures was performed. The most successful of the various techniques tried was that of taking the planar structure shown in figure 21 and placing the quarter-structures, one on each slant side of a pyramid. The angle between opposite slant sides of the pyramid is the ψ angle of the structure.

As can be observed from the figure, one structure is $\tau^{1/4}$ the size of the other. A very well-defined circularly polarized beam (at $\phi = 90°$, $\theta = 90°$) is obtained. The enlarged view of the feed point shows that, in general, two adjacent quarter-structures are fed against the remaining two quarter-structures; two and three are being fed against four and one. The sense of the circular polarization can be reversed by simply switching the feed point, or by feeding three and four against one and two.

Four experimental patterns over approximately a half-period are shown in figure 22. As can be seen, the axial ratio r as measured on the beam axis varied from 1.05 to 2 over this range. Since the patterns for the linearly polarized components (E_θ and E_ϕ) are very similar, it is expected that good circular polarization is obtained over most of the beam.

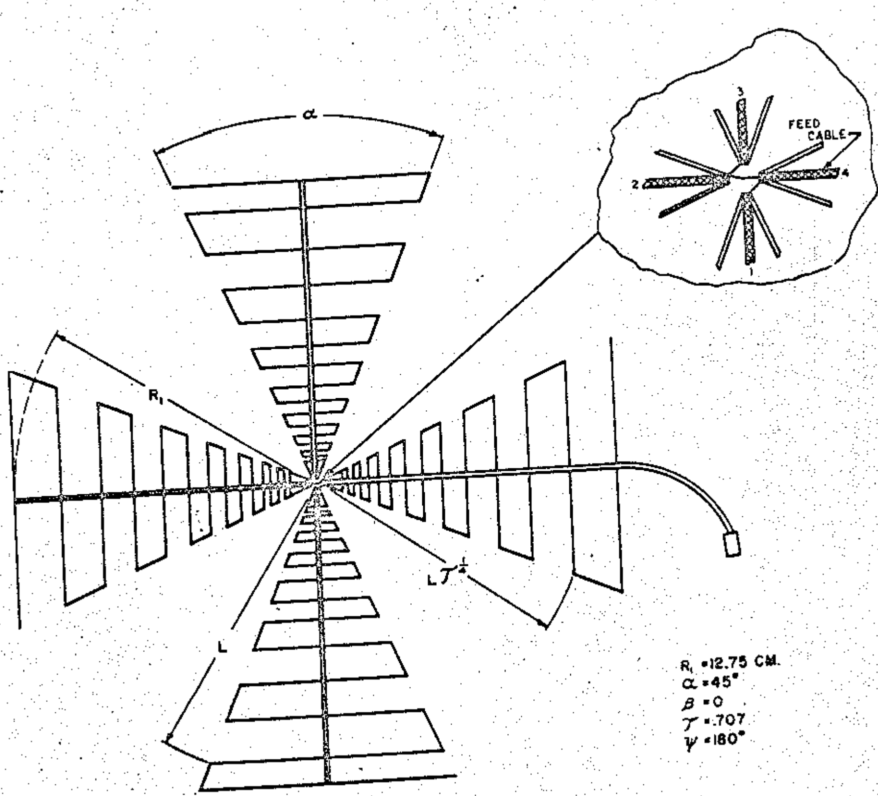


Fig. 21 Wire, trapezoidal-tooth, circular-polarized structure.

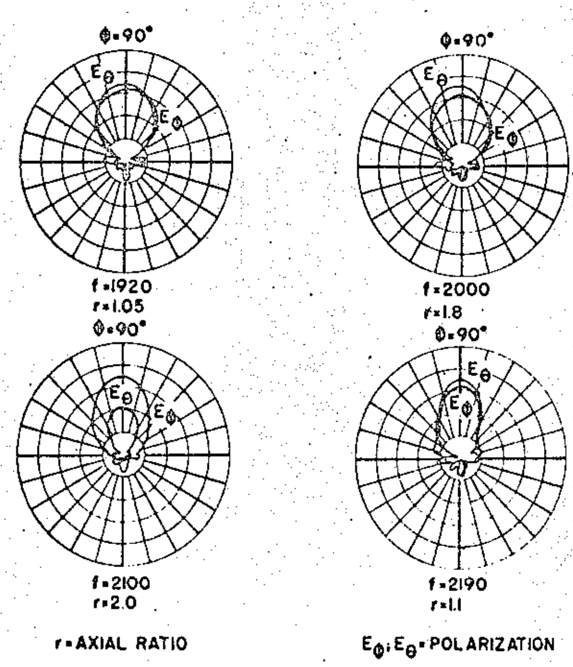


Fig. 22 XY plane patterns of circular-polarized pyramidal structure.

Current Distribution Measurements

An attempt was made to measure the magnitude and phase of the currents flowing on the elements of a typical nonplanar, wire, trapezoidal tooth structure. The current distribution was very complex and the results were not too conclusive. However, it was observed that, as the magnitude of the currents was measured from the vertex out toward the longer transverse elements, a point of maximum current magnitude was reached. From this point, the magnitude of the current decreased to more than 30 db below its value at the maximum point. The transverse elements at this low current point were much longer than a half wavelength of the operating frequency. This tends to demonstrate that end effects are negligible on these structures, which must be the case for wide band operation. As would be expected, the point of maximum current magnitude shifted toward the vertex of the structure as the frequency was increased.

Conclusions

Many types of logarithmically periodic antenna structures have been built and tested. Most of those which gave essentially frequency independent operation have been reported here but there were many structures for which the pattern and/or impedance were quite frequency sensitive. Unfortunately, no theory has been established which even predicts the types of structures which will give frequency independent operation. The equicomplementary condition (for planar structures) is sufficient to insure frequency independent impedance but not patterns. All of the planar structures (even those that don't work) may be considered as cross sections of frequency independent three-dimensional angular structures so that this approach leads nowhere. Thus, it is felt that a theoretical investigation of this class of antennas would be most fruitful.

Nevertheless, a small amount of effort has led to the discovery of structures which give a wide variety of essentially frequency independent radiation characteristics over practically unlimited bandwidths. One of many possible applications is for flush-mounted microwave antennas. Here, unidirectional structures can be placed in cavities with the cavity having little influence on the electrical characteristics because of the unidirectional pattern.

Acknowledgment

Special thanks are due Dr. R. L. McCreary for his support and tolerance and to Forrest G. Arnold who constructed and tested many of the models.

References

1. R. H. DuHamel and D. E. Isbell, "Broadband Logarithmically Periodic Antenna Structures," 1957 I.R.E. National Convention Record, Part I, pp. 119-128

2. V. H. Rumsey, "Frequency Independent Antennas," 1957 I.R.E. National Convention Record, Part I, pp. 114-118

3. J. D. Dyson, "The Equiangular Spiral Antenna," University of Illinois, Antenna Laboratory TR #21 September 15, 1957, Contract AF 33(616)-3220

4. D. E. Isbell, "Non-Planar Logarithmically Periodic Antenna Structures," University of Illinois, Antenna Laboratory TR #30, February 20, 1958, Contract AF 33(616)-3220

United States Court of Appeals
FOR THE EIGHTH CIRCUIT

No. 19,000

University of Illinois Foundation, Appellant, v. Winegard Company, Appellee.	Appeal from the United States District Court for the Southern District of Iowa.

[September 30, 1968.]

Before MATTHES, MEHAFFY and LAY, Circuit Judges.

LAY, Circuit Judge.

The plaintiff, the University of Illinois Foundation, appeals from a judgment below denying patent validity to its United States Letters Patent No. 3,210,676,[1] relating to a "frequency independent unidirectional antenna." The plaintiff is the owner by assignment from one Dwight E. Isbell. For facility of discussion we refer to the patent itself as the "Isbell Patent." Suit was brought against the defendant Winegard Company for alleged infringement. Trial was held before the Honorable Roy L. Stephenson, Chief Judge of the Southern District of Iowa. Judge Stephenson held that the subject matter of the patent did

1 Plaintiff's assignor filed his application for patent on May 3, 1960.

not rise to the level of patentability and dismissed plaintiff's suit. See *University of Illinois Foundation* v. *Winegard Co.*, 271 F.Supp. 412 (S.D. Iowa 1967).

The Isbell Patent claims a high quality television antenna for color reception, with unidirectional performance over a wide bandwidth of frequencies. The trial court denied validity to the patent in that "it would have been obvious to one ordinarily skilled in the art and wishing to design a frequency independent unidirectional antenna to combine . . . prior art references. . . ." *Id.* at 419.

There is no necessity to set forth the full discussion of the facts relating to the prior art. These appear in the excellent analysis made by the Chief Judge below. We have examined the record and find that all claims must be denied, lacking nonobviousness as a matter of law for essentially the same reasons set forth by the court below.

Plaintiff urges that the trial court erred in denying patent validity and calls our attention to a subsequent decision in a federal district court in Illinois which upholds the validity of the same patent against another defendant, *University of Illinois Foundation* v. *Blonder-Tongue Laboratories, Inc.*, N.D. Ill., Civ. No. 66 C 567. However, as recognized by the district court in Illinois, we must determine this case on its own record.[2]

The plaintiff basically urges on appeal that the district court in the present case erred in finding that "those skilled in the art at the time of the Isbell application knew . . . the log periodic method of designing frequency independent antennas." On the face of the record we must

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2 Compare this court's holding in *Imperial Stone Cutters, Inc.* v. *Schwartz*, 370 F.2d 425 (8 Cir. 1966), invalidating the letters patent previously upheld in 1958 by another panel of our court on a different record in *Ezee Stone Cutter Mfg. Co.* v. *Southwest Indus. Prods., Inc.*, 262 F.2d 183 (8 Cir. 1958).

agree that this finding is erroneous. The record discloses that the log-periodic formula[3] for antenna design was a recognized theory within the calling. This formula is discussed in the authoritative article by Drs. Hamel and Ore entitled *Logarithmically Periodic Antenna Designs,* published in March of 1958. However, as pointed out by plaintiff, this same article discloses:

> "Unfortunately, no theory has been established which even predicts the types of structures which will give frequency independent operation."

Jasik's Antenna Engineering Handbook, a recognized authority in the field, verifies on page 18: ". . . it is not possible to determine *a priori* the frequency independent type of log-periodic antennas." The record is clear that both plaintiff and defendant experts agreed with this fact.

Thus, we feel the evidence only discloses the adaptation by plaintiff of the log-periodic formula to obtain geometric proportional spacing across its bandwidth. It did not teach that said spacing will in itself achieve frequency independent operation. As we view the record it is the achievement of frequency independent operation through the use of the dipole array which is the principal claim of the Isbell patent. Both parties' experts agree that with frequency independent operation "severe end-effects" and

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3 As summarized by the trial court:

"Generally stated, log periodic antennas are designed according to the theory that an antenna 'design cell' having high performance characteristics for reception of a limited band or period of radio frequency signals, if altered in all dimensions by a constant scale factor will have high performance characteristics for reception of a band of signals having wavelengths which vary from the wavelengths of the first band of frequencies by the same constant scale factor. Thus, according to the theory, if an antenna design cell has certain characteristics for reception of particular frequency wavelengths, an antenna geometrically similar but reduced in all dimensions by a scale factor of .5 will have similar characteristics for reception of frequencies of wavelengths half those of the first." *University of Illinois Foundation* v. *Winegard Co.*, 271 F.Supp. 412, 417 (S.D. Iowa 1967).

unstable performance is avoided. A frequency independent antenna is one in which the basic electrical characteristics remain substantially constant over a given frequency range. These characteristics generally relate to uniform gain, bandwidth, directivity and a good impedance match. Unless an antenna achieves frequency independent operation it will not offer the high quality performance over a wide band of frequencies needed for commercial operation.

However, we *do not* view the acknowledged fact of the unpredictability of the frequency independent operation of the Isbell patent as requiring us to reach a result different than held below. Nor was the trial court's finding in this regard essential to its overall reasoning that the patent itself was made obvious by the prior art. The statutory standard of patentability under § 103 is not "predictability." This terminology helps to obscure the true issue of "nonobviousness." The valid test relates the subject patent to whether its development would be obvious to one skilled in the art. As stated by Mr. Justice Clark, the test of nonobviousness "is *one of inquiry, not* quality . . .." *Graham* v. *John Deere Co.,* 383 U.S. 1, 17 (1966). As we have often repeated, such inquiry relates to: (1) scope and content of the prior art, (2) differences between the subject patent and the prior art, (3) the level of the skill in the art at the time involved and (4) secondary considerations relating to commercial success, long-felt need, et al. And of course, the latter factors cannot alone determine patentability. *National Connector Corp.* v. *Malco Mfg. Co.,* 392 F.2d 766 (8 Cir. 1968).

Therefore, we deem the sole legal issue in the instant case to be whether a person skilled in the calling could improve with the skill of the calling the prior art by obvious means.

The mere fact that the "invention" was not previously known or developed is not the test. Where logical exploration within known principles of the science achieves an unpredictable result, even though a commercially desirable one, the burden of nonobviousness is not necessarily overcome. In other words, the necessity of logical experimentation does not in and of itself negate obviousness.[4] Cf. *General Mills, Inc.* v. *The Pillsbury Co.*, 378 F.2d 666 (8 Cir. 1967).

As early asserted by Mr. Justice Bradley in *Atlantic Works* v. *Brady*, 107 U.S. 192, 199-200 (1882):

> "The process of development in manufactures creates a constant demand for new appliances, which the skill of ordinary head-workmen and engineers is generally adequate to devise, and which, indeed, are the natural and proper outgrowth of such development. Each step forward prepares the way for the next, and each is usually taken by spontaneous trials and attempts in a hundred different places. To grant to a single party a monopoly of every slight advance made, except where the exercise of invention, somewhat above ordinary mechanical or engineering skill, is distinctly shown, is unjust in principle and injurious in its consequences."

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4 In *Minnesota Mining & Mfg. Co.* v. *Coe*, 99 F.2d 986, 989 (D.C. Cir. 1938), the court said:

> "But a showing of great industry in experimental research is not in itself sufficient to constitute invention, when the product thereof differs from those of the prior art only in degree and the result—no matter how useful it may be—is merely one step forward in a gradual process of experimentation."

In *Busell Trimmer Co.* v. *Stevens*, 137 U.S. 423, 435 (1890), the United States Supreme Court said:

> "But the patent before us is no such case. The most that can be said of it is that it shows, on the part of Orcutt, great industry in acquiring a thorough knowledge of what others had done in the attempt to trim shoe soles in a rapid and improved mode, by the various devices perfected by patents for that purpose, good judgment in selecting and combining the best of them, with no little mechanical skill in their application; but it presents no discoverable trace of the exercise of original thought."

Plaintiff urges Isbell had to overcome two serious handicaps which hid the developmental obviousness: (1) the use of linear dipoles to achieve a broad-band result, and (2) the mismatch of impedance. The simple answer *to this argument* is that the "problems" presented were never recognized beyond experimental correction by those skilled in the calling. Although linear dipoles may have been used with "narrow-band" antennas, such configuration had been shown to be used with antennas having broad-band characteristics. Defendant's tests demonstrated they had substantially the same characteristics (except impedance) as the "folded dipole." They had been utilized interchangeably by experimental engineers. These equivalent characteristics were known long before the Isbell patent.

The problem of matching impedance was one of adjustment. However, matching impedance is an elementary problem to those skilled in radio electronics. Impedance is recognized as the resistance to the flow of current. It is fundamental that efficient performance of any antenna occurs only through a maximum power transfer of the transmission line to the antenna itself. This requires matching impedance as much as possible. No claim of "invention" is asserted to overcome the mismatch, only that the antenna itself was, therefore, not obvious. The ability to match impedance with the linear dipole array was not new to the development and exploration which led to the Isbell antenna. There was not involved the same deterrent as experienced in *United States* v. *Adams*, 383 U.S. 39 (1966), where chemicals were interchanged, admittedly non equivalents, to achieve the "water battery." Nor is it claimed that the subject patent "embrace(s) elements having an interdependent functional relationship." *United States* v. *Adams,* 383 U.S. at 50. The problem here was one of trial and error with a combination of commonly used elements operating within known principles of electronics and mechanics to achieve a desired result. Cf. *Marconi Wireless Tel. Co.* v. *United States,* 320 U.S. 1 (1942).

In Jasik's Antenna Engineering Handbook it is stated on page 1813:

> "Since log-periodic antennas are too complex to analyze by present-day theoretical methods, they must be investigated by *logical experimental methods.*[5] However their repetitive nature greatly simplifies the initial experimental investigation because the characteristics need only be measured over one or two periods of frequency." (Emphasis ours.)

Plaintiff claims that the frequency independent operation of the Isbell antenna was accomplished by "specified scaling factors to determine dipole length, design cell dimensions, and spacing between dipoles." Here again, the evidence reflects that plaintiff did nothing more than logical and mechanical experimentation within suggested principles and design from the existing art. As the trial court found, there exists a direct relationship between the length and cell dimension of the Isbell claims and those of the prior art found within the K. O. antenna. And plaintiff's own expert discounted the significance of the dipole spacing as a design factor.

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5 Mr. Winegard of the defendant company relates the experimental engineers' approach:

> "Well, in the early days I used to calculate the resonance. There's so many factors with respect to the length of the element—if you are just concerned with one dipole, one straight dipole, it would be very easy to determine the actual length by calculation, but when you place several elements together there is always an interaction which will affect the length, so in order to get optimum performance from an array it is necessary to tune the antenna by slightly modifying the actual length of the—I have been working with antennas so long it is like learning the English language, you don't have to look at the dictionary every time to figure out how to spell 'and.' You know what I mean?"

Problems of impedance, patterns, resonance, gain, directivity and bandwidth, may all vary upon experimentation within recognized principles of elements having known interrelated electrical characteristics. And naturally, only high quality performance will be the optimum design array desirable. Such experimental combination of common elements and principles, e.g., *dipole array, transposed feed, end fed* and *log-periodic formula*, by selected spacing to obtain an improvement of both antenna design and performance, does not obviate the test of nonobviousness. If this were not true, at least in the instant case, nonobviousness would depend simply upon achieving a new result. The standard of patentability under § 103 requires more.

Judgment affirmed.

A true copy.

Attest:

Clerk, U. S. Court of Appeals, Eighth Circuit.

IN THE

Supreme Court of the United States

October Term, 1968.

No. 993

UNIVERSITY OF ILLINOIS FOUNDATION,
Petitioner,
vs.
WINEGARD COMPANY,
Respondent.

RESPONDENT'S REPLY TO PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE EIGHTH CIRCUIT AND PETITIONER'S REQUEST FOR DELAYED CONSIDERATION.

Keith J. Kulie,
Donald B. Southard,
29 South LaSalle Street,
Chicago, Illinois 60603,
Area 312-236-3351,
Attorneys for Respondent.

Of Counsel:
Kulie & Southard,
29 South LaSalle Street,
Chicago, Illinois 60603.

THE GUNTHORP-WARREN PRINTING COMPANY, CHICAGO

antenna or as a receiving antenna. In other words, the directional characteristic is evidenced in the radiation pattern, the input impedance of the structure, the polarization, or field which is produced, and (Tr. 165) these properties are all the same for a transmitting antenna or a receiving antenna. However, it is easier to understand the operation of transmitting antennas in general than it is to understand the operation of receiving antennas.

Considering this, therefore, as a transmitting antenna, we would have a source of radio frequency energy, shown schematically here by a circle with a half sine wave described therein. This source of radio frequency energy of a particular frequency within the operating band of the

Q. Did the effort to develop log-periodic antennas continue unabated at least until 1960?

A. Yes.

Q. How many successful log-periodic antennas were developed during that period?

A. Three or four.

Q. How many attempts were made to develop log-periodic antennas?

A. Many.

104

(Tr. 164) Q. Could you give us an estimate of what you mean by many?

A. I would say many models were constructed using the concept of the repeating cells. However, only a few of these gave the desired frequency independence performance. As far as an exact number of many, I would say they would run in the 10s.

Q. 20, for example?

A. 20, 30.

Q. What was the difficulty in designing operable log-periodic antennas?

A. There are two principal difficulties. One of these has been referred to as the end effect. Once again, Your Honor, I think the blackboard would be of use in describing what we mean by end effect. Suppose I refer to this particular structure which is, as we have said, a successful frequency independent variety of log-periodic structure, and let's consider it, for reasons of simplicity in the discussion, as a transmitting antenna, although we have heard Mr. Harris testify as an expert that the important electrical properties of an antenna are not really dependent upon whether the antenna is being used as a transmitting

TABLE OF CONTENTS.

AUTHORITIES CITED.

Cases.

EXCERPTS FROM RECORD.

103

slot antenna you also have some information about the sheet metal antenna.

Q. I believe you testified that the inventor of this antenna which you have just described was Prof. DuHamel, who was at the University at that time?

A. Yes.

Q. And what year was that?

A. Approximately 1957.

(Tr. 163) Q. Incidentally, who assigned the name log-periodic to antennas of this type?

A. Prof. DuHamel.

Q. Can you describe briefly any subsequent log-periodic antennas that came after this, the one you have just described?

A. Yes, the next most significant development in the log-periodic antenna field was the achievement of a unidirectional rediation pattern, whereby the radiation on one side of the antenna was suppressed and the directional beam was produced on the other side of the antenna. This performance was achieved by Dwight Isbell in his work at the University of Illinois Antenna Laboratory and he achieved this type of performance by spoiling the symmetry of the original log-periodic antenna. This was obtained by bending the elements out of the plane in a manner which reduced the radiation in one direction to negligible values.

of defendant's president, the interaction which always exists when several elements of an antenna are placed together.

CONCLUSION.

It is submitted that the present case presents an exact parallel with the facts which faced the Supreme Court in the *Adams* case. Here, as in *Adams*, a combination of elements was made, in spite of the knowledge and predictions of the prior art that indicated failure, to achieve an unpredictable result involving the interdependent functional relationship of the several elements. The decision of the Supreme Court in the *Adams case* is therefore fully applicable in the instant situation.

For the foregoing reasons appellee requests an opportunity for a rehearing on these points. Because of the fundamental nature of the question presented, it is requested that the rehearing be before the entire Court, sitting in banc.

Respectfully submitted,

CHARLES J. MERRIAM,
WILLIAM A. MARSHALL,
BASIL P. MANN,
30 West Monroe Street,
Chicago, Illinois 60603,
Area Code 312-346-5750,
Attorneys for Appellant.

Of Counsel:
MERRIAM, MARSHALL, SHAPIRO & KLOSE,
30 West Monroe Street,
Chicago, Illinois 60603,
COOK, BLAIR, BALLUFF & NAGLE,
409 Putnam Building,
Davenport, Iowa 52801.

IN THE

Supreme Court of the United States

OCTOBER TERM, 1968.

No. 993.

UNIVERSITY OF ILLINOIS FOUNDATION,
Petitioner,

vs.

WINEGARD COMPANY,
Respondent.

RESPONDENT'S REPLY TO PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE EIGHTH CIRCUIT AND PETITIONER'S REQUEST FOR DELAYED CONSIDERATION.

OPPOSITION TO REQUEST FOR DELAYED CONSIDERATION OF PETITION.

Petitioner has requested that consideration of its petition be delayed until the Court of Appeals for the Seventh Circuit has rendered a decision in a case now before it (PB 1, 11).*

The parties and much of the subject matter of the Seventh Circuit case are distinct and not related to the *Winegard* case. The record developed in the case tried in the Seventh Circuit (PB 11), now on appeal to the Court

* Note: Each reference designated "PB" herein refers to Petitioner's Brief and the page number therein.

of Appeals for the Seventh Circuit (PB 1), of course, is substantially different from the record developed in the *Winegard* litigation. It also should be noted that the Court of Appeals for the Eighth Circuit specifically alluded to Judge Hoffman's decision.[1]

Petitioner, in support of its request for delayed consideration, also notes that "there are several instances of probable infringement in circuits other than the Seventh or Eighth in which validity of the Isbell patent *may be* litigated." This appears as a plea to delay consideration until such time as another Court of Appeals renders a conflicting decision thereby enhancing the probability of securing the attention of this Court. The plea is not responsive to any stated right of Petitioner or of the need for reasonably expeditious resolution of this conflict. We respectfully submit that Respondent should not be subject to an indefinite delay in the final resolution of its case by reason of the incident of other litigation now pending which may or may not state a different conclusion regarding validity of a patent involved in both suits.

1. "Plaintiff urges that the trial court erred in denying patent validity and calls our attention to a subsequent decision in a federal district court in Illinois which upholds the validity of the same patent against another defendant, *University of Illinois Foundation* v. *Blonder-Tongue Laboratories, Inc.*, N. D. Ill., Civ. No. 66 C 567. However, as recognized by the district court in Illinois, we must determine this case on its own record" (PB 2A).

serviceable to a given need may require a high degree of originality. It is that act of selection which is the invention' . . ."

One Skilled in the Art Would Have Been Deterred From Making Isbell's Combination.

In its decision, this Court distinguished the decision of the Supreme Court in *United States* v. *Adams*, 383 U. S. 39 (1966), on the ground that there was no deterrent which faced those in the art who sought to achieve Isbell's result. It is respectfully submitted that the Court erred.

Rather than having a reasonable prospect for success in designing a log-periodic antenna, one skilled in the art would have expected failure and thus would have been deterred from even making the attempt. The knowledge that only a few successful log-periodic antennas were found among the many log-periodic structures which had been designed and tested is, in effect, a teaching away from such structures for one seeking to design a frequency independent antenna. What is obvious to one skilled in the art depends, of course, on the knowledge possessed by those skilled in the art at the time the invention is made. This knowledge would hardly suggest that a log-periodic structure employing simple dipoles would obviously function in a frequency independent manner.

II. The Isbell invention involves elements having an interdependent functional relationship.

The Court erred when it stated in its opinion that no claim was made that Isbell's combination involved an "interdependent functional relationship" ofelements. Such a claim was made on pages 17 and 20 of appellant's Brief and on pages 6 and 7 of appellant's Reply Brief. Moreover, the decision of the Court, page 7, footnote 5, shows, in the words is not undertaken with complete blindness but rather with some semblance of a chance of success, and that patentability determiations based on that as the test would not only be contrary to statute but result in a marked deterioration of the entire patent system as an incentive to invest in those efforts and attempts which go by the name of 'research'." (Emphasis in original.)

In the present case, there was no indication that Isbell's combination of elements was any more worthy of research than any other of the countless combinations which could have been made. Further, not only does the record show that others at the University of Illinois tried and failed to achieve the Isbell type of antenna (R. 103, 104), it also shows that there was a serious need for such an antenna which others had failed to satisfy (R. 123-125). The fact that this need existed and that others had not even pursued the idea of a log-periodic dipole array, is an additional indication that such a pursuit was not obvious.

Without the so-called "log-periodic theory of antenna design", which this Court found the lower court erroneously assumed to exist, an antenna designer, at the time the invention of Isbell was made, would have been faced with the problem of selecting blindly or by trial and error, the single effective combination of elements made by Isbell from the vast number of such combinations which could be made and which would not work. Further, the log-periodic theory is by no means the only approach to antenna design. There were many other basic approaches from which the designer had to make a selection. The Court of Appeals for the Second Circuit held in *Frank W. Egan & Co.* v. *Modern Plastic Machinery Corp.*, 387 F. 2d 319, 323 (1967):

"As Judge Learned Hand phrased it in *B. G. Corp.* v. *Walter Kiddie & Co.*, 79 F. 2d 20, 26 USPQ (2 Cir. 1935): 'All machines are made up of the same elements * * * But the elements are capable of an infinity of permutations, and the selection of that group which proves

REPLY TO PETITION FOR WRIT OF CERTIORARI.

We submit that the questions set forth in Petitioner's brief (PB 2-3) avoids expression of the significant issue in this case. Accordingly, we present our statement of the question before this Court.

QUESTION PRESENTED.

Whether the district court and the Court of Appeals for the Eighth Circuit properly applied the nonobvious test of 35 U. S. C. § 103 in determining that the patent in suit did not involve patentable subject matter.

STATEMENT OF CASE.[2]

This action was instituted by Petitioner when it filed a complaint in the United States District Court for the Southern District of Iowa alleging infringement of Letters Patent 3,210,767. Petitioner is the owner by assignment of said patent.

The decision of the District Court is set forth in the appendix attached to the petition (PB 10A-23A). The District Court stated that ". . . it can be seen that an antenna with the general parameters of Isbell patent[3] will result from a combination of the dipole array of Katzin[4] with the transposed feeder line of the Channel Master

2. Petitioner's statement of the case is primarily argumentative and not a concise statement of the facts material to the consideration of the question presented.

3. U. S. Patent 3,210,767.

4. U. S. Patent 2,192,532.

"K. O."[5] or the Koomans[6] or Winegard[7] patents." The District Court concluded that "... upon full consideration of the record herein (the Court), finds that the disclosure of Isbell Patent No. 3,210,767 is lacking in the prerequisite nonobviousness and is, therefore, invalid" (PB 22A-23A).

The Court of Appeals for the Eighth Circuit affirmed the decision of the District Court (PB 1A-9A) and stated:

> "We have examined the record and find that all claims (of the Isbell patent) must be denied, lacking nonobviousness as a matter of law for essentially the same reasons set forth by the court below." (PB 2A—parenthetical expression added.)

5. One of the antennas cited as prior art, produced and marketed by the Channel Master Corporation of Ellenville, N. Y. between September 1954 and December 1958 (PB 16A).

6. U. S. Patent 1,964,189.

7. U. S. Patent 2,700,105.

Unpredictability of Result Cannot Be Ignored in Determining Nonobviousness.

The Court dismisses the unpredictability of Isbell's invention as merely tending "to obscure the true issue of 'nonobviousness'." Granting that the statutory standard is "nonobviousness," appellant nevertheless submits that predictability is a major factor to be considered in resolving the issue. As the C. C. P. A. said in *Application of Pantzer*, 341 F. 2d 121, 126 (1965):

> "In other words, an invention can be said to be obvious if one ordinarily skilled in the art would consider that it was logical to anticipate with a high degree of probability that a trial of it would be successful."

In this case, not only was there no "high degree of probability" of success, exactly the opposite was true. One skilled in the art who might have contemplated making Isbell's combination would have anticipated failure with a high degree of probability.

The "obvious-to-try" test applied by this Court is not sufficiently discriminatory. This is a most unrealistic approach to the results of research, which is contrary to statute (35 U. S. C. 103), which provides that "Patentability shall not be negatived by the manner in which the invention is made.", and one which has been criticized by the courts. In *Application of Tomlinson*, 363 F. 2d 928, 931 (1966), the C. C. P. A. repected the argument that the invention involved only "routine experimentation", saying:

> "Our reply to this view is simply that it begs the question, which is obviousness under section 103 of *compositions* and *methods*, not of the direction to be taken in making *efforts* or *attempts*. Slight reflection suggests, we think, that there is usually an element of 'obviousness to try' in any research endeavor, that it

This petition is based on the following points:

1. The standard of obviousness applied by the Court is improper and will result in the complete destruction of our entire patent system. If the mere fact that known elements are intentionally combined renders the combination unpatentable, even though the result is unpredictable and the combination is made without a reasonable prospect for success, then only *accidental discoveries will be patentable, because there* are no new elemnts which can be combined.

2. The Court's allegation that appellant did not claim the patented invention to "embrace elements having an interdependent functional relationship" is erroneous. The decision of the Supreme Court in *United States* v. *Adams,* 383 U. S. 39 (1966), is fully applicable to this case.

Argument.

I. The court applied the wrong standard to the issue of obviousness.

The log-periodic dipole antenna array covered by the Isbell *patent in suit is admittedly a combination of old* elements. In its decision, the Court conceded the following:

1. There was no reference teaching the design of log-periodic antennas.

2. The individual elements of the Isbell antenna array could be connected in countless combinations and variations involving the selection of these elements, the manner in which these elements are combined, and the size and spacing of these elements.

3. No one could predict which, if any, of these countless combinations would give the results obtained by Isbell.

ARGUMENT.

THE STANDARD TO DETERMINE WHETHER SUBJECT MATTER IS PATENTABLE IS SET FORTH IN 35 U. S. C. SECTIONS 101 AND 103, WITH SECTION 103 REQUIRING NON-OBVIOUS SUBJECT MATTER.

Patents are granted only for developments which are new, useful and non-obvious to one having ordinary skill in the art. The patent laws do not require that there be "invention" but rather that there be statutory unobviousness.

Hard work in studying the discoveries and acquiring the ideas of others, the exercise of good judgment in selecting them and skill in applying them to practical results do not involve the creation of patentable subject matter. All such activity must be measured against the state of the art and, of course, must satisfy the standard of patentability.

The content of the prior art must be determined by the mandates of this Court as set forth in *Graham* v. *John Deere Co.,* 383 U. S. 1, 17 (1966). There is was stated:

> * * * the § 103 condition, which is but one of three conditions, each of which must be satisfied, lends itself to several basic factual inquiries. Under § 103, the scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness or nonobviousness of the subject matter is determined.* * *

The standard by which the District Court and the Court of Appeals for the Eighth Circuit determined that the Isbell development did not involve patentable subject matter is the standard expressed by this Court in *Graham, supra.* Both courts examined the prior art to determine the scope and content thereof; both courts evaluated the differences between the Isbell development and the prior art examined and both courts, in light of this examination, determined that the Isbell antenna did not involve non-obvious subject matter.

Petitioner concedes that such an examination and determination was made but contends that both courts erred in the basic determination and failed to properly consider the significance of other secondary aspects (PB 7).

PETITIONER'S CONTENTION THAT THE COURT OF APPEALS APPLIED THE WRONG STANDARD OF PATENTABILITY IS NOT CORRECT.

Petitioner contends that the Court of Appeals applied the wrong standard of patentability (PB 6), further stating that the standard applied was contrary to that expressed by this Court in *Graham* v. *John Deere, supra.* This contention is predicated upon an alleged "unpredictability" with respect to the subject matter of the Isbell patent. We submit that the "unpredictability" attributed to the Isbell development is not supported by the record in the present controversy. In any event, we submit that Petitioner primarily seeks to obscure the real issue, namely, whether the Isbell antenna was obvious within the meaning of 35 U. S. C. 103.

The courts below applied the proper standard of patentability. The Court of Appeals for the Eighth Circuit, for example, in addressing itself to the statutory standard of patentability to be applied, pointed out with particularity that, as Mr. Justice Clark stated in *Graham* v. *John Deere, supra,* the test of nonobviousness is one of inquiry, not quality, and further set forth that such inquiry involves:

APPENDIX.

IN THE UNITED STATES COURT OF APPEALS

For the Eighth Circuit

No. 19000 Civil

UNIVERSITY OF ILLINOIS FOUNDATION,
Appellant,

vs.

WINEGARD COMPANY,
Appellee.

APPEAL FROM THE UNITED STATES DISTRICT COURT FOR THE SOUTHERN DISTRICT OF IOWA, DAVENPORT DIVISION.

APPELLANT'S PETITION FOR REHEARING IN BANC.

INTRODUCTION.

Now comes University of Illinois Foundation, plaintiff-appellant, and respectfully petitions for rehearing in banc af the Court's decision of September 30, 1968, which affirmed the District Court's ruling that the invention covered by the Isbell patent in suit was obvious in view of the prior art and that the patent is therefore invalid.

CONCLUSION.

We respectfully submit that Petitioner has not shown sufficient cause for granting the petition for a writ of certiorari.

Respectfully submitted,

KEITH J. KULIE,
DONALD B. SOUTHARD,
29 South LaSalle Street,
Chicago, Illinois 60603,
Area 312-236-3351,
Attorneys for Respondent.

Of Counsel:
KULIE & SOUTHARD,
29 South LaSalle Street,
Chicago, Illinois 60603.

"(1) scope and content of the prior art, (2) differences between the subject patent and the prior art, (3) the level of the skill in the art at the time involved and (4) secondary considerations relating to commercial success, long felt want, et al." (PB 4A.)

Even the most casual comparison confirms that the standard applied by the Court of Appeals is in complete harmony with that set forth in *Graham.*

Petitioner's real objection resides in the fact that the courts below refused to consider the factor of "unpredictability" as the test of patentable subject matter but adhered to the statutory standard expressed in 35 U. S. C. 103. However, it cannot be said that the Court of Appeals did not consider the factor of alleged "unpredictability" in relation to the Isbell subject matter, as Petitioner suggests. The Court was well aware of secondary considerations on the question of patentability and pointed out that "predictability" is not the test of patentability under section 103 and merely obscures the true issue of nonobviousness (PB 4A).

Many "secondary" tests have been referred to over the years. The Court of Appeals specifically referred to "commercial success, long-felt need, et al." (PB 4A). Besides "unpredictability", the "et al." includes such factors as: delay or failure of others to produce the subject matter; improved economy, efficiency or simplicity; tribute of competitor's imitation; extensive royalty agreements by competitors; supplanting of older, prior art structures; elimination of a technological block; prior unsuccessful efforts or experiments; citation of many prior art patents to anticipate disclosed subject matter. The foregoing list is not exhaustive but is intended to be representative of factors frequently considered by the Courts. In each case, the particular factor cannot in and of itself establish patentability where none exists. We consider it equally well established that such secondary considerations are applicable only where there is serious doubt as to whether certain subject matter is patentable. Accordingly, we submit that if an alleged factor of "unpredictability" is to be considered in a particular case, it necessarily must be of a secondary nature, rather than primary, and cannot, of itself, establish patentability.

Petitioner's Reasons and Arguments.

The Petitioner sets forth two grounds in alleging that the Court of Appeals erred in its decision. It is stated separately that "Unpredictability of Result Cannot Be Ignored in Determining Non-Obviousness" (PB 7) and "One Skilled in the Art Would Have Been Deterred From Making Isbell's Combination." (PB 10.)

It is significant to note that the argument under these headings is the same as that made to the Court of Appeals in the Petition for Rehearing to that Court. There is a slight modification of one (first) paragraph on page 8 of Petitioner's brief, as well as a relocation thereof, and the addition of one (last) paragraph on page 9. Petitioner's brief in support of its request for rehearing is set forth in the appendix attached (2A-5A). The Petition for Rehearing was denied and Petitioner now presents the same arguments to this Court.

The Alleged Factor of Unpredictability.

Petitioner states that "predictability" is a major factor to be considered in resolving the issue of obviousness and includes cases cited in support of this position (PB 7). We are unable to find such support in the cases cited. Petitioner relies upon *Application of Pantzer,* 341 F. 2d 121 (1965), for the proposition that to hold an invention ob-

The Court doubtless will be surprised to learn that they have "effectively" passed new legislation affecting patents. We have assumed the decision of the Court did not extend beyond a determination that the Isbell antenna did not involve nonobvious subject matter. There is no statement in the decision of the Court of Appeals which will support the argumentative conclusion stated by Petitioner.

Petitioner proceeds to note that:

> "The standard of obviousness cannot be as broad as that adopted by the Court of Appeals. * * * If the mere fact that known elements are intentionally combined renders a combination unpatentable, even though the result is unpredictable and the combination is made without a reasonable prospect for success, then only accidental discoveries will be patentable, * * *." (PB 12-13.)

A standard of patentability expressed in the terms of Petitioner's argument would necessarily contemplate the existence of patentable subject matter if:

(1) the result is unpredictable;

(2) the development is made without a reasonable prospect for success.

Even though this is a new proposal for a standard of patentability we can explore the result of application of the standard. Since the Court of Appeals, in quoting from the Jasik handbook, observed that "it is not possible to determine *a priori* the frequency independent type of log-periodic antennas" then all one need do to develop an antenna for which a patent must issue would be to experiment with any design not previously developed in that *exact* form. If it worked a patent would issue—the antenna need only be (1) new and (2) useful. Inquiry into the scope and content of the prior art would not be permitted with this standard of patentability.

on the one hand and a trial court decision on the other. Nor can we find any instance in which a writ of certiorari was in fact granted by this Court on the latter basis.

With respect to certiorari in patent infringement cases specifically, perhaps the language found in American Jurisprudence states it best. We find in 32 Am. Jur. 2d at 699:

> "Certiorari in patent infringement cases will be granted where validity and infringement are in doubt and further litigation resulting in conflict of decision among circuits is improbable because the petitioner is the only competitor in the business, but where there is no conflict between decisions of Courts of Appeal on the question whether a patent is invalid for anticipation or lack of invention, the writ will not be granted."
>
> (Citing: *General Talking Pictures Corp.* v. *Western Electric Co.,* 304 U. S. 175; *Keller* v. *Adams-Campbell Co.,* 264 U. S. 314.)

With reference to the foregoing passage we note that we do not have a case where the Petitioner is the only competitor in the business. Nor do we have a case where further litigation resulting in conflict of decision among circuits is improbable. Petitioner itself states that there are instances of alleged infringement in circuits other than the Seventh or Eighth in which the validity of the Isbell patent may be litigated. There is, of course, no conflict of decisions between Courts of Appeal. Accordingly, we submit there exists no proper foundation for this Court to grant a review by certiorari in the present case.

THE STANDARD OF PATENTABILITY APPLIED BY THE COURT OF APPEALS FOR THE EIGHTH CIRCUIT WAS PROPER.

Petitioner argues that the decision of the Court of Appeals in this case

> "... effectively denies the patentability of all combinations of known elements." (PB 12.)

vious one skilled in the art must anticipate success with "a high degree of probability." (PB 7.) Such language does appear in that case. The language, however, is taken out of context and standing by itself does not express the position of that Court. The three sentences immediately preceding the language cited by Petitioner provide a more definitive perspective with respect to the *Pantzer* decision, namely (126):

> "* * * The Appellant's position appears to be that we must be able to predict with certainty that those glycols will dissolve with methetharimide before rejection is proper here.
>
> However, as we pointed out in *In re Moreton,* 48 CCPA 928, 288 F. 2d 940, *obviousness does not require absolute predictability.* Where, as here, the knowledge of the prior art clearly suggests that the use of glycols as solvents in place of water to form solutions of methetharimide stable against hydrolysis would be successful, *the mere possibility of failure does not render their successful use unobvious."* (Emphasis added.)

The rule that obviousness does not require absolute predictability is well founded in the law. *In re Moreton* (1961), referred to by the Court in *Pantzer,* has repeatedly been relied upon in subsequent cases before the Court of Customs and Patent Appeals as well as by other Courts.[8] As such, it may be considered a significant decision on this question.

The *Moreton* case closely parallels the case at hand, with the exception that it deals with subject matter which is related to the chemical field rather than the electrical field.

8. See: *Application of Huellmantel,* 324 F. 2d 998 (1963); *Application of Pantzer and Feier, supra; Application of Graf,* 343 F. 2d 774 (1965); *Application of Crounse,* 363 F. 2d 881 (1966); *Application of Wilson,* 368 F. 2d 269 (1966); *Application of Miegel and Verbanc,* .... F. 2d ...., 159 USPQ 716 (1968); *Clinical Products, Ltd.* v. *Brenner, Comr. of Pats.,* 255 F. Supp. 131 (D. C., DC, 1966); *Clinical Products, Ltd.* v. *Brenner, Comr. of Pats.,* 255 F. Supp. 151 (D. C., DC, 1966).

The application in the *Moreton* case concerned a hydraulic fluid suitable for use, for example, in aircraft systems over a wide temperature range (—80°F. to 400°F.). The Court with respect to the statutory standard of obviousness stated at 288 F. 2d 940, 942:

> "We feel constrained to hold that the prior art possessed quite full knowledge of the use of appellant's orthosilicate component as hydraulic fluid and of its viscosity-temperature behavior. This brings the question of patentability of the claimed invention down to the obviousness of adding * * *"

The applicant (appellant) in *Moreton* sought to avoid the consequences of the prior art by raising the issue of "unpredictability". In this regard, the court pointed out (943):

> "Appellant bases considerable argument on a reference no longer relied upon by the Patent Office * * *. It is said to show that the addition of viscosity improving agents to lubricants does not give predictable results * * *."

With the foregoing as a background, the Court stated (943):

> "What this amounts to is an argument that if one slavishly following the prior art, albeit with a little educated imagination, will sometimes succeed and sometimes fail, then he is always entitled to a patent in case of success. That is not the intention of 35 U. S. C. 103. Obviousness does not require absolute predictability. Where, as here, the knowledge of the art clearly suggests * * *, the mere possibility of failure does not render their successful use 'unobvious'."

It should be observed that in the *Moreton* case, and in the present case, prior art is present that is shown to possess full knowledge of the subject matter in question and in each it is urged that "unpredictability" of results prevent the application thereof to avoid any conclusion of

one would necessarily be required to start with a clean sheet and disregard entirely the prior art. However, this type of posture was specifically criticized by this Court in *Mandel* v. *Wallace, supra.*

CONFLICT IN DECISIONS BETWEEN COURT OF APPEALS AND DISTRICT COURT SHOULD NOT BE SUFFICIENT GROUNDS FOR GRANTING CERTIORARI.

Petitioner notes that there is a conflict between the Court of Appeals decision in the present case and a decision by the District Court for the Northern District of Illinois with respect to the validity of the Isbell patent. While not stated in precise words, we infer that Petitioner contends that this is sufficient grounds for this Court to grant the requested writ of certiorari. We respectfully submit that to do so for this reason would clearly be contrary to the established precedent.

Moreover, as previously pointed out, there are significant differences in the record before this Court and the record on which the decision of the trial court in the Seventh Circuit is based. The Court of Appeals for the Eighth Circuit was quite aware of this District Court decision by Judge Hoffman but noted that its decision must be, as it was, decided on the record before it.

Reasons for granting a writ of certiorari are specifically enumerated in Rule 19(1)(b) of this Court. It is of course to be understood that the reasons as therein stated are neither controlling nor fully measure the Court's discretion in this regard. Among those reasons that are set forth for granting review by certiorari is the case where a Court of Appeals has rendered a decision in conflict with the decision of another Court of Appeals on the same matter. We note that no such reason is stated for granting the writ on the basis of a conflict of decision between a Court of Appeals

The patent in suit in the *Adams* case disclosed a non-rechargeable, water-activated battery having magnesium and cupurous chloride as the respective electrodes. As such, it more properly pertains to subject matter in the chemical art than in the electrical art, notwithstanding the device is a battery. This Court observed that it was the *first* practical, water-activated, constant potential battery. It exhibited operating characteristics which were entirely *unexpected* and surpassed *all* then-existing wet batteries. It is to the state of the prior art, however, which helps spotlight the non-obviousness of the Adams battery. The Court pointed out that despite a century and a half of advancement with respect to batteries prior to the Adams patent applications, the Patent Office could not find *one* reference to cite against the invention. In addition, experts had expressed disbelief in the invention. Prior art batteries from which the Adams battery was claimed to have been copied were long before discarded. Furthermore, one particular prior art reference (foreign patent) relied upon not only disclosed inoperative subject matter, but was in fact highly dangerous. An attempt to construct a battery according to its teachings first produced a fire, then an explosion when the battery was being assembled.

The Adams patent involved the interchanging of chemicals, which were non-equivalents, notwithstanding the teachings, or more correctly the absence of teaching, of the prior art to achieve the surprising "water battery," while Isbell merely incorporated (or substituted) known elements operating within known principles to achieve a desired result, which result, we might add, was to be expected. Frequency independent log-periodic antennas were shown to be well established in the prior art. Isbell was hardly faced with the same deterrent as Adams, as the Court of Appeals pointed out (PB 7A). To reach the same conclusion with respect to the Isbell combination as Petitioner advocates,

obviousness. Petitioner here is advocating the very concept denied in *Moreton* and by the Courts below in the present case. Petitioner suggests that notwithstanding the teachings of the prior art, a patent is sustainable for the simple reason that there was a mere possibility of failure in attaining each and every objective. In this sense the term "unpredictability" is not proper. Petitioner appears to be advocating "infallibility" or "prevision" as being necessary before an invention may be found obvious. These factors have been considered by the Courts. In *Naamlooze Venootschafs* v. *Coe, Commissioner of Patents,* 132 F. 2d 573, 575 (C. C. A. DC, 1942), it was stated:

> "It is true that anological reasoning is more restricted in chemistry than in the field of mechanics. (citations omitted). This is because chemistry is essentially an experimental science in which predictions cannot be made with the same certainty that they can be made in mechanics. (citations omitted) * * *. But from the facts that *prevision is not certain* in chemistry, that progress in the chemical art is reached largely through experiment, and that patents are often upheld where the inventor stumbles upon a discovery, * * *, *it does not follow that every new and useful result accomplished by experiment is patentable* (citations omitted)." (Emphasis added.)

An illuminating treatment on the question of absolute predictability (or infallibility) is found in *Hedman* v. *Commissioner of Patents,* 253 F. Supp. 515, 520 (D. C., DC 1966). The Court there stated:

> "* * * While utmost care must be exercised by chemical patent examiners and other ordinarily skilled chemists in making predictions based on the general rules of chemistry, on the ground that even the most reasonable predictions in this science often turn out to be wrong, this factor should not preclude 'a person having ordinary skill in the art' of chemistry from making reasonably based predictions on the basis of prior art knowledge.

With further regard to this alleged lack of predictability, little sophistication is required to distinguish between the undeniably true statement that there is no absolute predictability in chemistry on the one hand, and the erroneous statement that there is absolutely no predictability in chemistry on the other hand. An unequivocal holding to the effect that there is no predictability whatsoever in the science of chemistry would completely eliminate the obviousness test of 35 U. S. C. § 103 from consideration in determining the patentability of claimed chemical inventions. If there is no predictability in chemistry, then no new chemical invention would ever have been obvious at the time it was made to an ordinarily skilled chemist, and it would logically follow that any new and useful chemical invention would be patentable. Such elimination of the obviousness test of 35 U. S. C. § 103 in determining the patentability of chemical inventions would be quite contrary to statute law and to the clear intent of Congress in enacting Section 103 that the test should be applied in determining patentability of every 'invention,' whether chemical, mechanical, or electrical."

Petitioner nonetheless alleges that predictability is a major factor to consider in determining patentability. However, if there is no predictability concerning frequency independent operation for log-periodic antennas, then no new invention would ever have been obvious at the time it was made to an ordinarily skilled antenna designer and it would logically follow that *any* new and useful antenna structure would be patentable. Surely this cannot be the law for, as *Hedman* states, such a holding would completely emasculate the obviousness test under Section 103.

It might be well to offer a brief general comment with respect to the factor of unpredictability. It will be noted from the cases cited that it is a factor closely related to the chemical field. As pointed out in *Naamlooze Venootschafs, supra,* chemistry is essentially an experimental

Graham v. *Jeoffrey Manufacturing Inc.,* 206 F. 2d 769 (5 Cir., 1953).

With the foregoing in mind with respect to the record in the present case, we are unable to understand Petitioner's assertion that one ordinarily skilled in the art would have been deterred from making Isbell's combination. On the contrary, the reverse is true, and the Courts below could do little else but hold as they did. As stated by the trial court:

> "It is thus apparent that the Isbell antenna is a combination of elements, all known in the prior art and also that these known elements were combined in the Isbell antenna in a manner dictated by a theory also known in the prior art." (PB 21A.)

Contrary to Petitioner's assertion (PB 5), the "theory" referred to by the court is identified as "the log-periodic theory of antenna design."

THE COURT OF APPEALS WAS CORRECT IN DISTINGUISHING THE ADAMS CASE.

One last point we feel should be commented upon with respect to Petitioner's reasons for granting the Writ of Certiorari is the reference to the case of *U. S.* v. *Adams,* 383 U. S. 1. Petitioner suggests that the Court of Appeals erroneously distinguished the *Adams* case (PB 10). Also, it is suggested that the Court of Appeals must have concluded that there was no deterrent which faced those in the art who sought to achieve Isbell's result (PB 10). Reference to the Court of Appeals' decision will show that the Court stated that "there was not involved the same deterrent" in the present case as in *Adams* (PB 6A). It will be noted that Petitioner has changed "the same deterrent" to *no* deterrent. Be that as it may, one needs but a cursory examination of the *Adams* case to confirm that the Court of Appeals is correct in that the same deterrent is not present here.

DuHamel structure to zero, nothing more (R 191). Again, this is hardly selecting elements or structure arrangement "blindly", without purpose. The record clearly shows that the prior art suggests Isbell's combination. The only thing surprising would be if the combination failed to exhibit the expected result.

Petitioner represents to this Court that others at the University of Illinois

> "* * * tried and failed to achieve the Isbell type of antenna * * *" (PB 9).

Petitioner then refers to pages 103 and 104 of the Record in support of the statement. Pages 103 and 104 of the Record are set forth in the appendix hereto (7A-9A). There is no statement which even suggests the conclusion stated by Petitioner that others tried and failed to achieve the Isbell type of antenna. The representation is totally without support and is an improper conclusion which, we submit, represents nothing more than the ardent wish of Petitioner that the evidence and testimony were thus.

A point that should not be overlooked is that at least one other developed the subject matter disclosed in the Isbell patent at almost the same time as Isbell. The Isbell patent application was involved in an interference with an application filed in behalf of Alec Kravis and Mathew Fredrick Radford, Interference No. 92,150 (SR 113). While Isbell was ultimately successful on the question of priority, one cannot and should not ignore the fact, nor the implications with respect thereto, that others had in fact developed the same subject matter independently at substantially the same time. The case for patent validity is substantially weakened by this circumstance alone since it suggests that the means necessary to solve the particular problem is already in the public domain. *Audio Devices, Inc.* v. *Armour Research Foundation,* 293 F. 2d 102 (2 Cir., 1961);

science in which predictions may not be made with the same certainty as in mechanics. However, we are not persuaded that electrical or electronic subject matter should be considered as analogous to the chemical area rather than the mechanical area. We submit that any subject matter in the electrical arts is more susceptible to mathematical analysis than in the chemical arts, and perhaps even more than in the mechanical arts. To avoid making an issue of this point, we treat the matter as if predictability were a common factor in considering electrical patents. We submit that the same statutory standard of patentability is to be applied, whether the alleged invention is chemical, electrical or mechanical in nature. *Hedman* v. *Commissioner of Patents, supra.*

Consideration of the question of predictability has not been restricted to the Court of Customs and Patents Appeals and the District Court for the District of Columbia. This Court also has passed on the question. In *Mandel Bros., Inc.* v. *Wallace,* 335 U. S. 293 (1948), this Court was faced with the question of whether it constituted patentable invention to combine urea with a solution of aluminous sulphate in a cosmetic astringent preparation. The Courts below held that the use of urea as an anti-corrosive agent was a matter of public knowledge and that it had previously been used as a corrosion inhibitor in compounds other than antiperspirants. Nevertheless, the Respondent there, as the Petitioner here, argued that the prior art was irrelevant, for the teachings, if any, would not have led a chemist skilled in his art to undertake the experiment which resulted in success. What is particularly significant is that it was earnestly urged that urea combined with acid salts brought about a result contrary to what a skilled chemist would have concluded. Ergo, it was a "paradoxical" result, unpredictable by a skilled chemist. This Court addressed itself to this argument and stated at page 295:

"But we think that the state of the prior art was plainly sufficient to demonstrate to any skilled chemist searching for an anticorrosive agent that he should make the simple experiment that was made here.* * * As the United States Court of Appeals for the Second Circuit pointed out when this patent was before it '* * * skillful experiments in a laboratory, in cases where the principles of the investigations are well known, and the achievement of the desired end requires routine work rather than imagination, do not involve invention'."

THE ISBELL ANTENNA WAS OBVIOUS TO ONE HAVING ORDINARY SKILL IN THE ART AT THE TIME THE ANTENNA WAS MADE.

It should be noted that various statements set forth in the Petition have no foundation in the record. Petitioner contends, for example, that without the purported method for designing frequency independent log-periodic antennas relied upon by the Court below, there is no basis in the art for combining elements to make Isbell's combination (PB 8). We submit that this is inaccurate as well as an unwarranted play on words. Petitioner states that there is no method of designing "frequency independent log-period antennas" because it cannot be shown that one can predict with absolute and unswerving infallibility beforehand that all such fabricated log-periodic antennas will exhibit the desired frequency independence. However, it cannot be contested, and the Courts below so found, that a method of designing log-periodic antennas did and does exist (R 177), (PB 3A), a method which was well known in the art. Accordingly, there was every basis for combining elements to arrive at Isbell's antenna based on the teachings of the prior art. To arrive at a log-periodic antenna one must employ the design principles set forth in the known theory of log-periodic antenna design (R 177) (PB 3A),

deliberately, or at least unwittingly, but applied nevertheless.

To say, as Petitioner contends, that an antenna designer was faced with the problem of selecting blindly the single effective combination of elements from some vast number of possible, but inoperative, combinations is not true. The very most than can be said of Isbell's development is that simple dipoles were substituted in lieu of folded dipoles incorporated in a prior art structure (the Channel Master K. O. antenna, for example. R 197) which embodied the log-periodic design principles (PB 6A, 8A, R 35). The record is clear that simple and folded dipoles are electrically equivalent and have been utilized interchangeably by antenna engineers (*SR 49-51) (SR 131-142) (PB 6A). This hardly is selecting "blindly" from a "vast" number of possible combinations. Nor is this the only means of arriving at Isbell's combination. The trial court specifically pointed out that the Isbell patent will result from a combination of a prior art dipole array (Katzin Patent) and the transposed feeder line (Channel Master K. O. antenna *or* Winegard Patent *or* Koomans Patent) when the lengths and spacings are adjusted by the known log-periodic theory of antenna design (DuHamel & Ore article, R 177) (PB 20A, 21A). This is hardly "selecting blindly" elements and their arrangement in an antenna structure. Even the excerpt from an antenna engineering handbook (R 191) referred to by Petitioner in its brief before the Court of Appeals in support of the position that the design of frequency independent types of log-periodic antennas generally cannot be considered entirely predictable, points out how simply and easily the Isbell structure is derived from the prior art DuHamel structure. We are referring to the excerpt from Jasik's Antenna Engineering Handbook (DX-A-10b, R 191). It is there shown that to obtain the Isbell dipole array, one need only collapse all the angles in the

* SR—Supplemental Record.

McNENNY, FARRINGTON, PEARNE & GORDON

ATTORNEYS AT LAW

920 MIDLAND BUILDING

CLEVELAND, OHIO 44115

F. O. RICHEY (1878-1964)

HAROLD F. McNENNY
DONALD W. FARRINGTON
JOHN F. PEARNE
CHARLES B GORDON
ROBERT A. STURGES
WILLIAM A. GAIL
RICHARD H. DICKINSON, JR.
THOMAS P. SCHILLER
LYNN L. AUGSPURGER

TELEPHONE
(216) 623-1040
CABLE ADDRESS
RICHEY

PATENT AND
TRADEMARK LAW

LLOYD L. EVANS
OF COUNSEL

November 4, 1968

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HOFGREN, WEGNER, ALLEN, STELLMAN & McCORD

Robert H. Rines, Esq.
Rines and Rines
10 Post Office Square
Boston, Massachusetts 02109

Re: University of Illinois Foundation v. Winegard Company

Dear Bob:

I have finally received and am enclosing, herewith and with Dick Phillips' copy of this letter, a copy of the Foundation's petition for rehearing in the Winegard suit. I suspect they are shooting for a petition to the Supreme Court for a writ of certiorari. The pertinence of the law search enclosed with my last letter to you will be evident.

Incidentally, Dick found the materials which I asked him to look for. I received them only a few minutes before leaving on a trip last Wednesday and did not have time to let you know that you need not look for them in your files.

Sincerely,

John

JFP:jh
Enclosure

cc: Richard S. Phillips, Esq.

In the

United States Court of Appeals

For the Eighth Circuit

No. 19000
Civil

UNIVERSITY OF ILLINOIS FOUNDATION,
Appellant,

vs.

WINEGARD COMPANY,
Appellee.

APPEAL FROM THE UNITED STATES DISTRICT COURT FOR THE SOUTHERN DISTRICT OF IOWA, DAVENPORT DIVISION.

APPELLANT'S PETITION FOR REHEARING IN BANC.

CHARLES J. MERRIAM,
WILLIAM A. MARSHALL,
BASIL P. MANN,
30 West Monroe Street,
Chicago, Illinois 60603,
Area Code 312-346-5750,
Attorneys for Appellant.

Of Counsel:
MERRIAM, MARSHALL, SHAPIRO & KLOSE,
30 West Monroe Street,
Chicago, Illinois 60603,
COOK, BLAIR, BALLUFF & NAGLE,
409 Putnam Building,
Davenport, Iowa 52801.

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AUTHORITIES CITED.

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INTRODUCTION.

Now comes University of Illinois Foundation, plaintiff-appellant, and respectfully petitions for rehearing in banc of the Court's decision of September 30, 1968, which affirmed the District Court's ruling that the invention covered by the Isbell patent in suit was obvious in view of the prior art and that the patent is therefore invalid.

This petition is based on the following points:

1. The standard of obviousness applied by the Court is improper and will result in the complete destruction of our entire patent system. If the mere fact that known elements are intentionally combined renders the combination unpatentable, even though the result is unpredictable and the combination is made without a reasonable prospect for success, then only accidental discoveries will be patentable, because there are no new elements which can be combined.

2. The Court's allegation that appellant did not claim the patented invention to "embrace elements having an interdependent functional relationship" is erroneous. The decision of the Supreme Court in *United States* v. *Adams,* 383 U. S. 39 (1966), is fully applicable to this case.

ARGUMENT.

I. THE COURT APPLIED THE WRONG STANDARD TO THE ISSUE OF OBVIOUSNESS.

The log-periodic dipole antenna array covered by the Isbell patent in suit is admittedly a combination of old elements. In its decision, the Court conceded the following:

1. There was no reference teaching the design of log-periodic antennas.
2. The individual elements of the Isbell antenna array could be connected in countless combinations and variations involving the selection of these elements, the manner in which these elements are combined, and the size and spacing of these elements.
3. No one could predict which, if any, of these countless combinations would give the results obtained by Isbell.

Unpredictability of Result Cannot Be Ignored in Determining Nonobviousness.

The Court dismisses the unpredictability of Isbell's invention as merely tending "to obscure the true issue of 'nonobviousness'." Granting that the statutory standard is "nonobviousness," appellant nevertheless submits that predictability is a major factor to be considered in resolving the issue. As the C. C. P. A. said in *Application of Pantzer*, 341 F. 2d 121, 126 (1965):

> "In other words, an invention can be said to be obvious if one ordinarily skilled in the art would consider that it was logical to anticipate with a high degree of probability that a trial of it would be successful."

In this case, not *only* was there no "high degree of probability" of success, exactly the opposite was true. One skilled in the art who might have contemplated making Isbell's combination would have anticipated failure with a high degree of probability.

The "obvious-to-try" test applied by this Court is not sufficiently discriminatory. This is a most unrealistic approach to the results of research, which is contrary to statute (35 U. S. C. 103), which provides that "Patentability shall not be negatived by the manner in which the invention is made.", and one which has been criticized by the courts. In *Application of Tomlinson,* 363 F. 2d 928, 931 (1966), the C. C. P. A. rejected the argument that the invention involved only "routine experimentation", saying:

> "Our reply to this view is simply that it begs the question, which is obviousness under section 103 of *compositions* and *methods,* not of the direction to be taken in making *efforts* or *attempts.* Slight reflection suggests, we think, that there is usually an element of 'obviousness to try' in any research endeavor, that it is not undertaken with complete blindness but rather with some semblance of a chance of success, and that patentability determinations based on that as the test would not only be contrary to statute but result in a marked deterioration of the entire patent system as an incentive to invest in those efforts and attempts which go by the name of 'research'." (Emphasis in original.)

In the present case, there was no indication that Isbell's combination of elements was any more worthy of research than any other of the countless combinations which could have been made. Further, not only does the record show that others at the University of Illinois tried and failed to achieve the Isbell type of antenna (R. 103, 104), it also shows that there was a serious need for such an antenna which others had failed to satisfy (R. 123-125). The fact that this need existed and that others had not even pursued the idea of a log-periodic dipole array, is an additional indication that such a pursuit was not obvious.

Without the so-called "log-periodic theory of antenna design", which this Court found the lower court erroneously assumed to exist, an antenna designer, at the time the invention of Isbell was made, would have been faced with the problem of selecting blindly or by trial and error, the single effective combination of elements made by Isbell from the vast number of such combinations which could be made and which would not work. Further, the log-periodic theory is by no means the only approach to antenna design. There were many other basic approaches from which the designer had to make a selection. The Court of Appeals for the Second Circuit held in *Frank W. Egan & Co.* v. *Modern Plastic Machinery Corp.*, 387 F. 2d 319, 323 (1967):

> "As Judge Learned Hand phrased it in *B. G. Corp.* v. *Walter Kiddie & Co.*, 79 F. 2d 20, 26 USPQ (2 Cir. 1935): 'All machines are made up of the same elements * * * But the elements are capable of an infinity of permutations, and the selection of that group which proves serviceable to a given need may require a high degree of originality. It is that act of selection which is the invention' . . ."

One Skilled in the Art Would Have Been Deterred From Making Isbell's Combination.

In its decision, this Court distinguished the decision of the Supreme Court in *United States* v. *Adams*, 383 U. S. 39 (1966), on the ground that there was no deterrent which faced those in the art who sought to achieve Isbell's result. It is respectfully submitted that the Court erred.

Rather than having a reasonable prospect for success in designing a log-periodic antenna, one skilled in the art would have expected failure and thus would have been deterred from even making the attempt. The knowledge that only a few successful log-periodic antennas were found among the many log-periodic structures which had been designed and tested is, in effect, a teaching away from such structures for one seeking to design a frequency independent antenna. What is obvious to one skilled in the art depends, of course, on the knowledge possessed by those skilled in the art at the time the invention is made. This knowledge would hardly suggest that a log-periodic structure employing simple dipoles would obviously function in a frequency independent manner.

II. THE ISBELL INVENTION INVOLVES ELEMENTS HAVING AN INTERDEPENDENT FUNCTIONAL RELATIONSHIP.

The Court erred when it stated in its opinion that no claim was made that Isbell's combination involved an "interdependent functional relationship" of elements. Such a claim was made on pages 17 and 20 of appellant's Brief and on pages 6 and 7 of appellant's Reply Brief. Moreover, the decision of the Court, page 7, footnote 5, shows, in the words of defendant's president, the interaction which always exists when several elements of an antenna are placed together.

CONCLUSION.

It is submitted that the present case presents an exact parallel with the facts which faced the Supreme Court in the *Adams* case. Here, as in *Adams,* a combination of elements was made, in spite of the knowledge and predictions of the prior art that indicated failure, to achieve an unpredictable result involving the interdependent functional relationship of the several elements. The decision of the Supreme Court in the *Adams* case is therefore fully applicable to the instant situation.

For the foregoing reasons appellee requests an opportunity for a rehearing on these points. Because of the fundamental nature of the question presented, it is requested that the rehearing be before the entire Court, sitting in banc.

Respectfully submitted,

Charles J. Merriam,
William A. Marshall,
Basil P. Mann,
30 West Monroe Street,
Chicago, Illinois 60603,
Area Code 312-346-5750,
Attorneys for Appellant.

Of Counsel:
Merriam, Marshall, Shapiro & Klose,
30 West Monroe Street,
Chicago, Illinois 60603,
Cook, Blair, Balluff & Nagle,
409 Putnam Building,
Davenport, Iowa 52801.