NOV 23 '59

Pueblo College
A PUBLICLY SUPPORTED COUNTY JUNIOR COLLEGE
Pueblo, Colorado

VOCATIONAL-TECHNICAL DIVISION

Nov 25, 1959

Wesley R. Schum
Central Electronics, Inc.
1247 W. Belmont Ave.,
Chicago 13, Ill.

Dear Wes,

Mr Gerald Caduff KØIQZ has come up with an idea for a revolutionary method of creating single sideband. He is the head of our Electronics department and an electrical engineer.

Although there are several advantages to this system the chief advantage is - there is no need to suppress the unwanted sideband as it is not generated.

There may be some error in our thinking. If we should consult you further on this matter would you sign an agreement with us not to use the method or divulge the method to others until some further agreement might be made with you. In return we would offer you the first chance to develop the unit if the plan is feasible.

I heard your 100V for the first time Saturday. P. A. Smoll WØKVD in Colorado Springs is real happy with his unit

Sincerely yours

73 Don Middleton

Don Middleton WØNIT
Communications Instructor

ZENITH RADIO CORPORATION

PHONE
BERKSHIRE 7-7500

ZENITH® RADIO and TELEVISION

CABLE ADDRESS
"ZENITHRAD"
ALL CODES

6001 DICKENS AVENUE CHICAGO 39, ILLINOIS

June 20, 1961

Mr. Wesley R. Schum, Vice-Pres.
Central Electronics, Inc.
1247 West Belmont Ave.
Chicago 13, Illinois

Dear Mr. Schum:

At your request a novelty search has been conducted with respect to the single side band generator described in the attached disclosure. Very briefly, the generator employs a cathode ray tube having X and Y deflection plates and a collector anode. An amplitude modulated carrier is applied in phase quadrature to both the X and Y plates, and the electron beam is intensity modulated with either the X or Y signal. A mask of particular configuration, apparently not yet determined, is disposed in front of the collector anode in order to eliminate the carrier and one side band, thereby producing only a single side band in the collector anode.

The basic concept as outlined above was not found in the patent literature. The closest art uncovered was patent 2,201,323 - Shelby, issued May 21, 1940, a copy of which is attached; it illustrates a cathode ray tube arrangement for frequency modulating a carrier. An amplitude modulated carrier is applied, in 90° phase displaced relation, to both the X and Y deflection plates of the cathode ray tube. By constructing the target anode in a particular spiral fashion, it is possible to convert the amplitude modulations to frequency modulations.

Several systems have been developed in which cathode ray tubes and uniquely shaped masks or target anodes are employed to achieve various results. Some of them are illustrated in the following attached patents which may be of general interest to you:

OCT 26 1960

PP 1-10 MD 12-21-60

SINGLE SIDEBAND GENERATION
with
GATED CATHODE RAY

The following paper does not purport to cover all the aspects of engineering and design to be encountered in the fabrication of the proposed unit, but rather to introduce a new concept in the generation of a single sideband signal. This unit, if feasible to manufacture, could boast of the following advantages: nearly 100% carrier suppression, nearly 100% unwanted sideband suppression, automatic and complete control of modulation percentage, instantaneous monitoring of the sideband alignment, which can be adjusted while in operation, complete independence of frequency operation, visual monitoring of sideband quality while operating, absence of critical audio phase-shift network, lack of microphone "hot-spots", capable of being driven by any existing V.F.O., and extreme simplicity of operation, by comparison.

The basic principle of the unit is the addition of a modulated carrier to the 90° phase-shifted inverse function of the same modulated frequency, at the fundamental frequency to be radiated. This forms a control parameter into which is injected a quadrature modulated carrier, again the same signal as above. A variation would be to inject a double sideband signal, thereby effecting carrier suppression prior to injection; however, this is unnecessary, as will be shown later. The method of quadrature addition is the crux of the developement.

The heart of the unit is a cathode-ray tube employing a collector anode, filter mask, and conventional electron gun and electrostatic deflection plates. Two 90° displaced signals are applied to the X and Y axes, which are the deflection plates of the CRT. The resulting circle is then modulated by the application of the same modulated signal to the control or intensity grid of the CRT. This signal can be either the 0° or the 90° voltage on the deflection plates. As modulation occurs , concentric circles are caused to expand and contract; simultaneously, portions of the rings are blanked by the modulated control grid. Adjustment of this "intensity" would be critical as severe frequency distortion could result with improper bias. A mask is inserted between the electron gun and the collector anode which removes the carrier and one sideband, leaving only one sideband signal to travel on to the collector anode. Properly shaped mask and collector anode made of fine mesh screen wire could allow a few electrons to strike the phosphor screen of the CRT, thereby giving continuous monitoring of the phasing, modulation amplitude, and quality. After the initial engineering and design of the tube filter mask and collector anode, standard CRT components could be used through-out, including the glass envelope and phosphor screen. The cost should be low and the size of the CRT is optional. A two inch screen is believed to be adequate and convenient for application.

Henceforth, voltages, frequencies, or signals applied to the vertical plates will be referred to as the Y axis parameters; those applied to the horizontal plates will be referred to as the X axis parameters, and those applied to the cathode stream, the Z axis parameters. It is now obvious that the three quadrature signals are applied to the X,Y, and Z axes of the CRT and their relative frequencies are the key to the sideband generation.

The fundamentals involved are set forth briefly in the following equations and diagrams. It should be understood that no attempt, as yet, has been made to carry the entire design through to its final form, but rather a compilation of notes, ideas, mathematical considerations, and laboratory data has been made and is presented herein; however, much of the obvious detail has been omitted.

Initially we assume an amplitude modulated wave:

$$e = A \cos wt + \frac{E_m}{2} \cos 2\,pi\,(f_1 + f_2)t + \frac{E_m}{2} \cos 2\,pi\,(f_1 - f_2)t$$

Conditions: $e = e_x = e_z$; also $e_y = e + 90°$

Setting modulation percentage to 0, then $e = A \cos wt$, $e_y = A \sin wt$
The resultant of e_y on the Y axis and e_x on the X axis is the addition of e_x to the inverse function of e_y and the pattern is a circle.
See figure 1. The perimeter of the circle represents a phase displacement from 0° to 360° of the carrier combination.
Introducing an amplitude modulated carrier to the X and Y axis, e_y being phase-shifted 90° results in concentric rings changing in diameter and percentage of modulation is a function of their radii.

Time duration from 0° to involute m,n, at modulated level of ring #1 represents a phase displacement of 90°, ring #2, 135° and ring #3 results in 180°. This establishes the frequency discrimination with respect to modulation amplitude. It is evident at this point that this unit could phase modulate as well as frequency modulate. These are other possible applications.

The Z axis is the cathode ray beam current modulated with e_z.
If E_m is 0, r=0, where r is the radius of concentric circles produced by the modulated carrier on X and Y and E_m is modulation amplitude. The term "r" is radius of gyration. See figure #3.
Therefore: $E_m = 0$, $r = 0$, e_z must equal A cos wt. The terms of the upper and lower sidebands drop out because there is no modulation.
It is evident now that if E_m is greater than 0, then r must be greater than 0, and the following signal exists on the collector anode.

$$e_z = A \cos wt + \frac{E_m}{2} \cos 2\,pi\,(f_1 + f_2)t + \frac{E_m}{2} \cos 2\,pi\,(f_1 - f_2)t$$

HD 12-21-60

Referring to figure #2, it can be seen that if a filter mask were to be placed between the beam origin and the collector anode and shaped to block only the beam when $E_m = 0$, then no collector anode current would or could flow and the term A cos wt would drop from e_z, thereby effecting carrier suppression. When E_m is greater than 0, and the beam extends beyond the filter mask to encounter collector anode, then r is greater than 0 and the anode current would be a function of e_z with carrier removed, i.e.,

$$I_c \cong f\left[\frac{E_m}{2} \cos 2pi\ (f_1 + f_2)t + \frac{E_m}{2} \cos 2pi\ (f_1 + f_2)t\right].$$

Since the upper and lower sidebands can be represented by counter-rotating vectors superimposed on the carrier, the relative position of the beam at any given time will represent modulation in the relation to radius of gyration and frequency with respect to angular displacement from any reference, such as 0° as in figure #1. It might seem at first consideration that this would result in only a phase displacement from the carrier but as the modulation frequency increases or decreases the phase control of the deflection on X and Y increases and decreases simultaneously. A phase displacement of a given sideband at any instant can be an actual frequency difference from the carrier between the limits of cos 2pi $(f_1 - f_2)t$ to cos 2pi $(f_1 + f_2)t$. Hence, a mask at the largest radius will limit the percentage of modulation and a mask at the center will remove the carrier under the conditions stated in the previous paragraph. It is believed, and the rigorous mathematical proof is currently under investigation, that the intercepts in the X-Y plane of the quadrature carrier e_z will define an area which includes either sideband to the exclusion of the other.

An analytical approach from the standpoint of logic, rather than theoretical mathematics, could yield this conclusion: the position of the electron beam at any instant is dependent upon the modulated carrier, phase shifted, on the abscissa and ordinate. Also the intensity of the beam, on or off, is dependent upon the modulated carrier but is now a quadrature function. Assuming that the upper sidebands cause normal vector rotation and the lower produce clockwise rotation (simple vector analysis bears this out) and that some reference "0" be assumed at zero modulation, then symmetry to 180° from 0° and 0° to -180° will result with modulation. Relating this to amplitude will show a pattern containing upper and lower sidebands with controlled percentages of modulation establishing the parameters of mask pattern.

Since the pattern must exceed 180° for a change in frequency (upper or lower sideband added) the pattern follows along due to the following of the deflection system, which is a function of the carrier. Hence, it would appear that a mask could be devised to remove any portion of the modulated signal desired. An analytical investigation of the total area as intercepted by the inverse function of e_z in the X-Y plane between the limits defined by $\frac{E_m}{2} \cos 2pi\ (f_1 + f_2)t$ or $\frac{E_m}{2} \cos 2pi\ (f_1 - f_2)t$ will yield the shape of the filter mask to pass or filter the desired sideband.

A limited empirical proof of this hypothesis has been accomplished by using an opaque mask over a cathode ray oscilloscope screen and a photoelectric pick-up. A HICKOK oscilloscope, model 620, and a BELL and HOWELL film projector amplifier, model 13817 were arranged as shown in figure #4 and were used in investigation the content of the signal derived from the face of the scope in accordance with the foregoing hypothesis. Although inconclusive, these tests and experiments yielded data that substantiated, in part, the design. It is felt that the proper design of a cathode ray tube eliminating the photoelectric aspect, would provide the necessary proof. Because of the persistency of the screen phosphor, these foregoing tests were confined to audio frequencies.

12-21-60

The exact shape of the filter mask has not yet been determined and, because of many variables that can best be learned empirically, it is believed that the actual shape may need to be modified from the theoretical to compensate for fringing of the electron beam, a function of the tube parameters and operating potentials.

Conceivably, the anode and filter mask could be of a fine mesh screen. Proper bias could then allow free passage of electrons to the phosphor screen for alignment purposes. A high negative bias on the mask would then gate the beam according to the physical shape of the mask, but the positive potential on the anode would allow some electron passage to the phosphor screen thus providing a pattern for contineous indication of operating conditions. The anode current would be in the microampere range; however, preamps would provide adequate output.

12-20-60

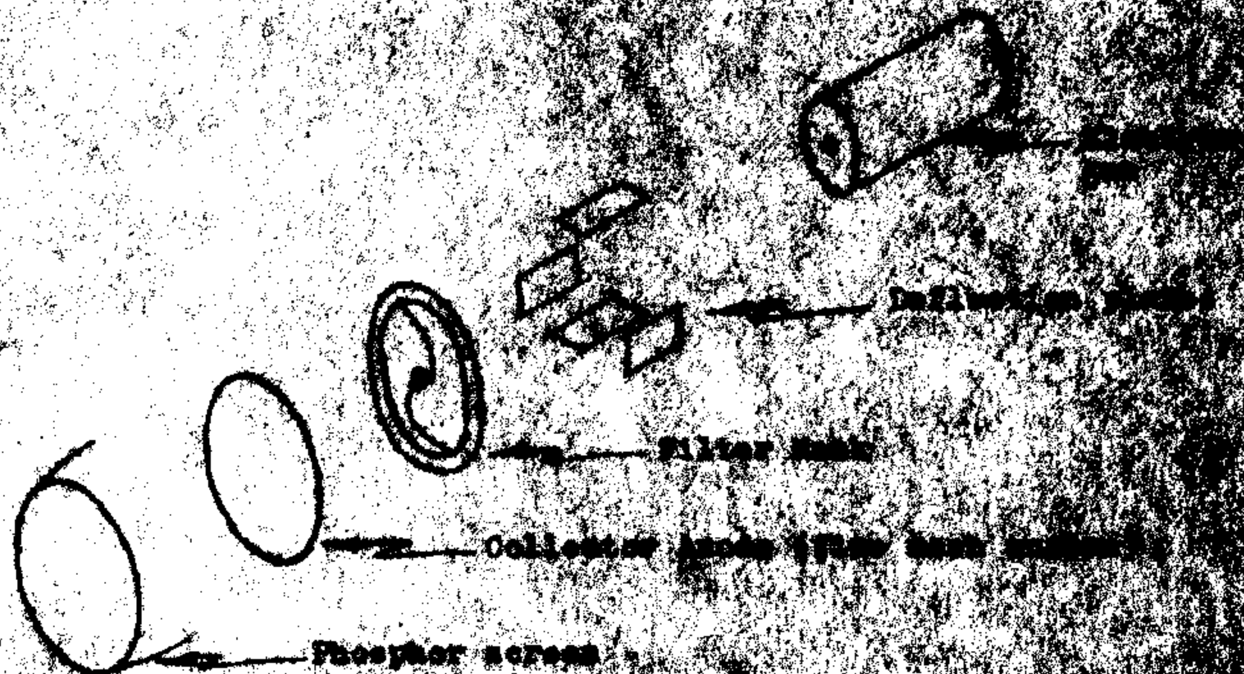
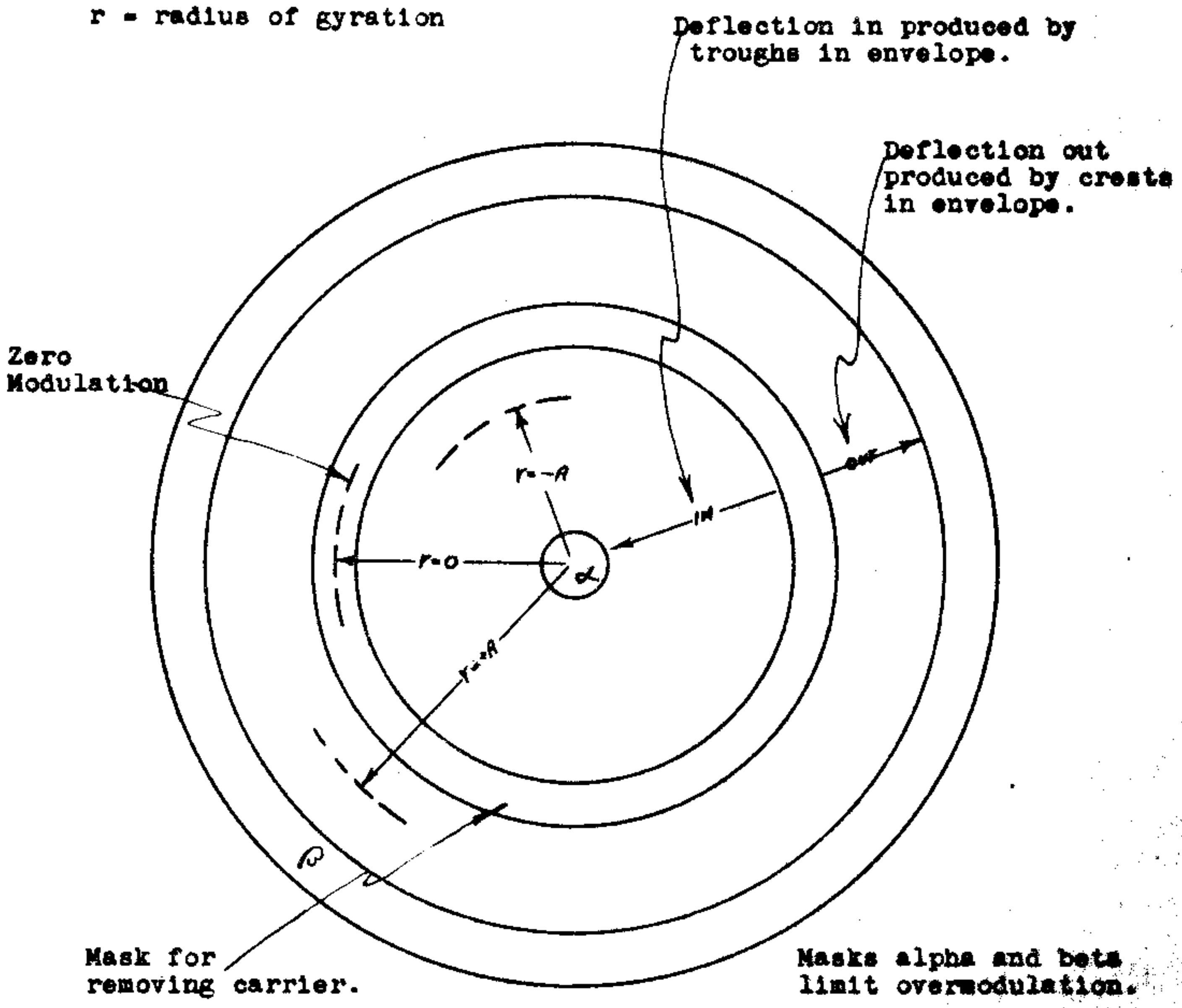


FIGURE No. 2



Deflection is dependent entirely upon amplitude of modulation and is not a function of frequency other than no deflection results with no modulating frequency applied.

FIGURE No. 3

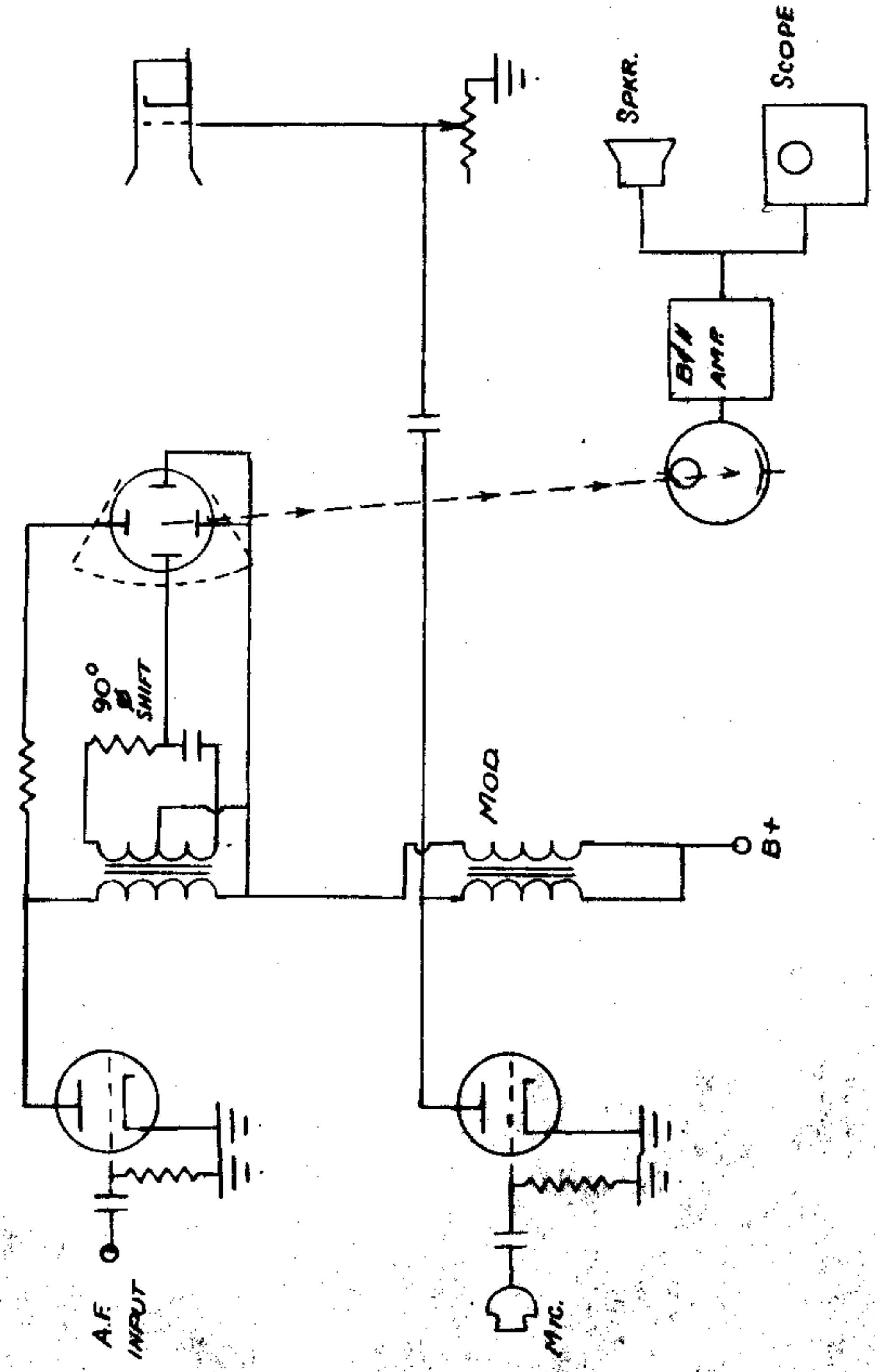
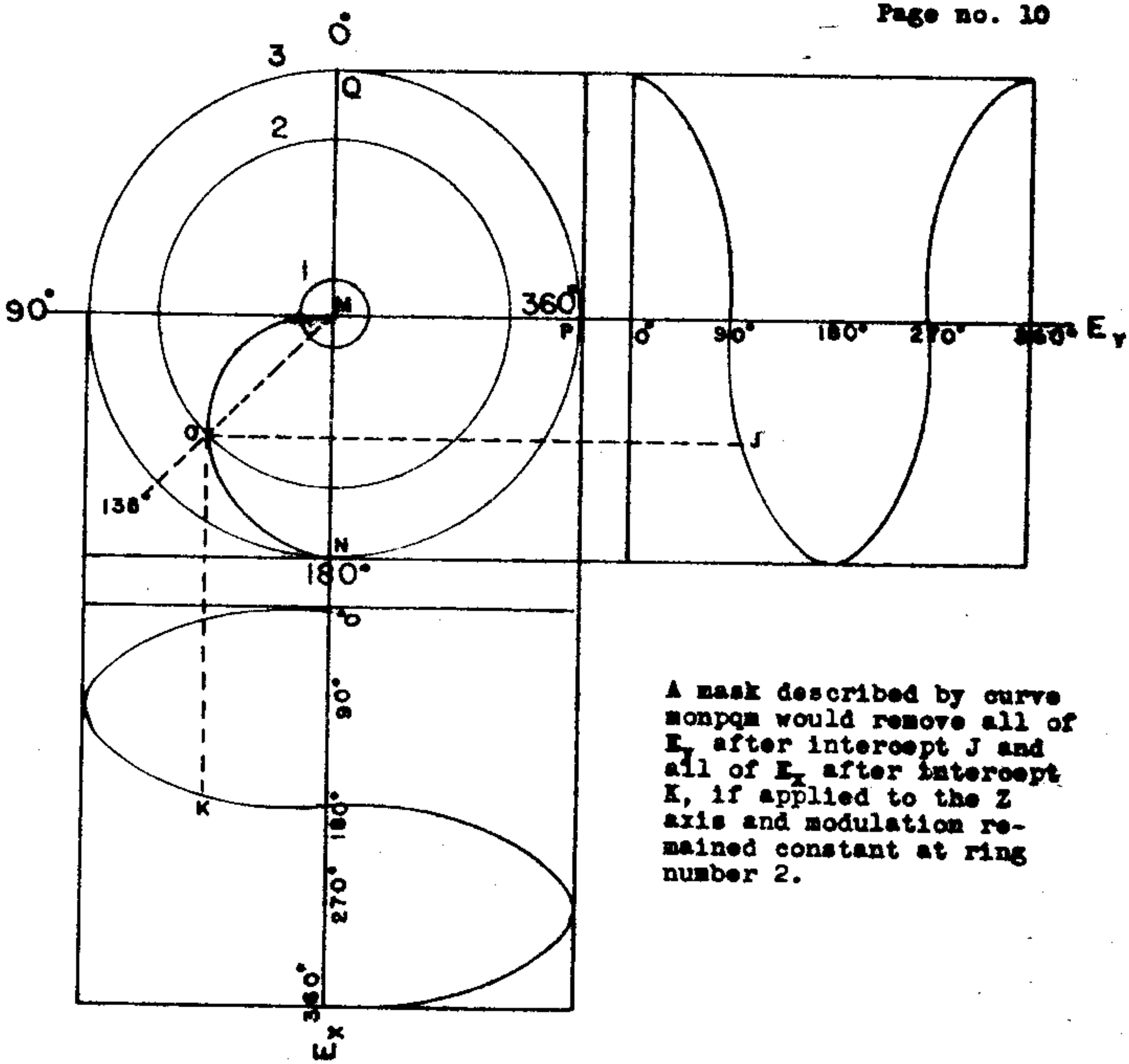


FIGURE No.4

12-21-60



A mask described by curve monpqm would remove all of E_y after intercept J and all of E_x after intercept K, if applied to the Z axis and modulation remained constant at ring number 2.

By G.F.Caduff
238 Veta Ave.
Pueblo, Colo.

12-21-60

FIGURE No. 1

cc: Mr. Hugh Drake, ZRC

26 January 1962

Mr. Don Middleton, [illegible]
Communications Instructor
Pueblo College
Pueblo, Colorado

Dear Don

Reference is made to the proposal submitted by you and Gerald Cadoff for generating single sideband.

I am enclosing a group of patents that involve cathode ray tubes with uniquely-shaped masks or target anodes employed to achieve various results. Our patent department is of the opinion that your concept does represent patentable subject matter--at least to a limited extent.

Recently Zenith Radio Corporation decided to defer the activities of Central Electronics from the communications field into products more closely associated with the home entertainment field. Accordingly, Central Electronics or Zenith Radio Corporation would have no further need for items such as described in your proposal.

I want to extend my personal best wishes for success in this product should you choose to pursue it.

Sincerely yours

CENTRAL ELECTRONICS, INCORPORATED

Wesley R. Schum
Vice President and Sales Manager

dw

Enclosures