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United States Patent [19] Gledhill et al.

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[54] RECEPTION OF ORTHOGONAL FREQUENCY DIVISION MULTIPLEXED SIGNALS

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[51] Int. Cl.⁵ **H04J 1/00; H04J 11/00**

[52] U.S. Cl. **370/19; 370/23; 370/69.1; 375/120**

[58] Field of Search **370/19, 20, 21, 23, 370/69.1, 121, 122; 375/119, 120, 83; 364/725, 726**

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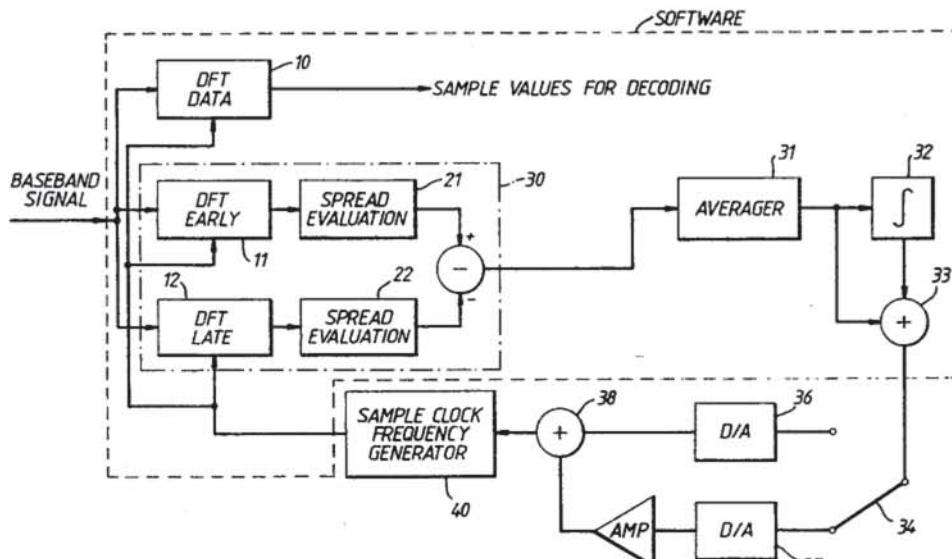
Assistant Examiner—Melvin Marcelo

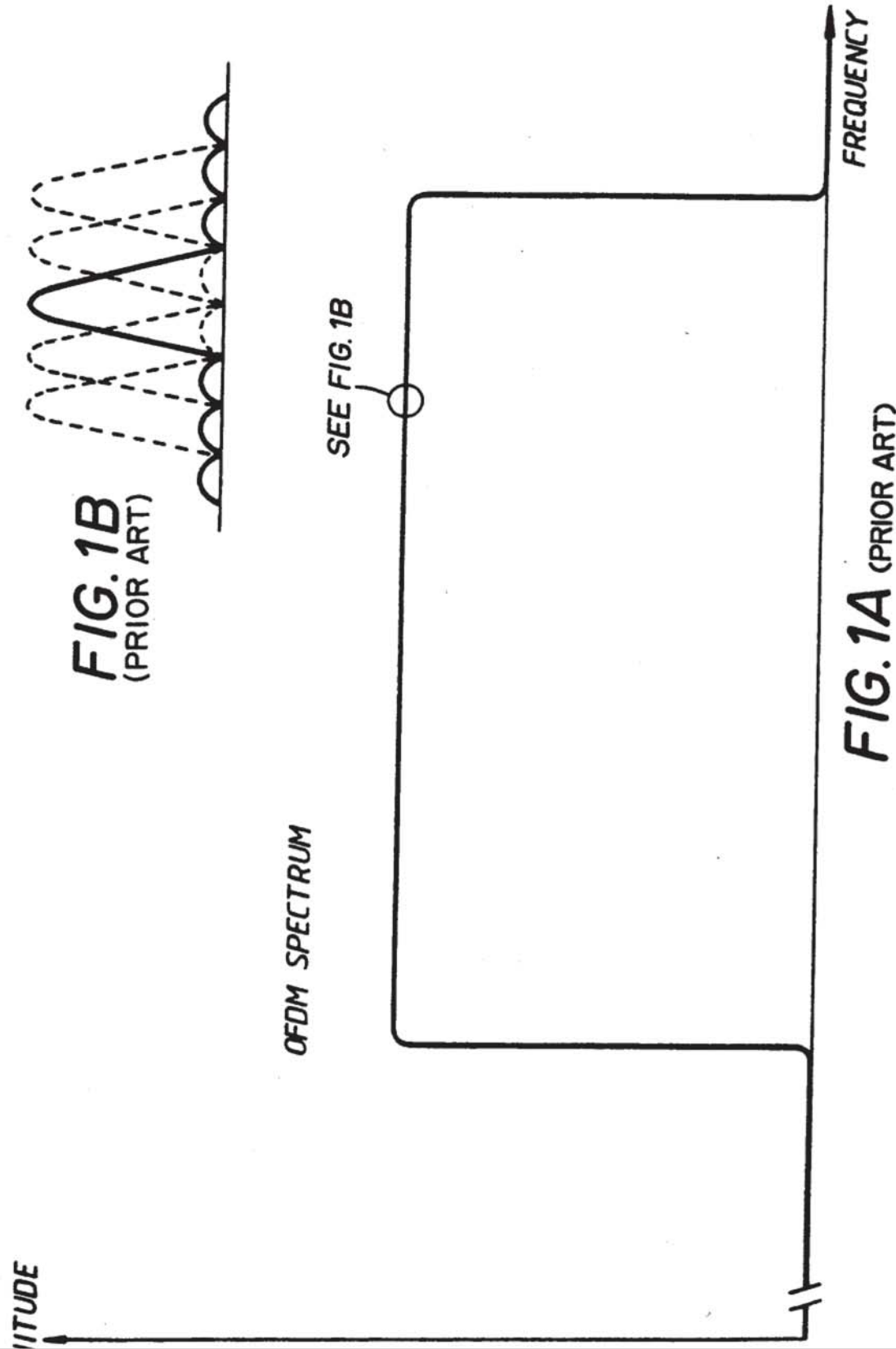
Attorney, Agent, or Firm—Watson Cole Grindle & Watson

ABSTRACT

[57] In an OFDM signal individual OFDM carriers are modulated by samples of signals which can only take a limited range of allowed values and a block of samples modulates the group of carriers during a time period T. In a receiver, the signal modulating an individual OFDM carrier may be demodulated by estimating the position of reference axes serving as the frame of reference against which the allowed modulating values are defined, and multiplying the value of the demodulated samples by the complex conjugate of a point on one of the estimated reference axes. The spread of the groups of samples demodulated from each OFDM carrier gives an indication of whether the receiver is synchronised to the block boundaries. Preferably spread of the complex samples is evaluated in the radial direction only and used to steer the sample clock frequency. Phase drift of the demodulated samples from one block to the next indicates the degree of local oscillator frequency error. Preferably phase drift is assessed by multiplying complex values by the complex conjugate of an earlier sample demodulated from the same OFDM carrier and using the resulting measure to steer the local oscillator frequency via a frequency locked loop.

17 Claims, 11 Drawing Sheets





E.G. INITIAL STATE = $+1+j$

| DATA | TRANSITION | FINAL STATE |
|------|------------|-------------|
| 00 | 0° | $+1+j$ |
| 10 | 90° | $-1+j$ |
| 11 | 180° | $-1-j$ |
| 01 | 270° | $+1-j$ |

Fig. 2A
(PRIOR ART)

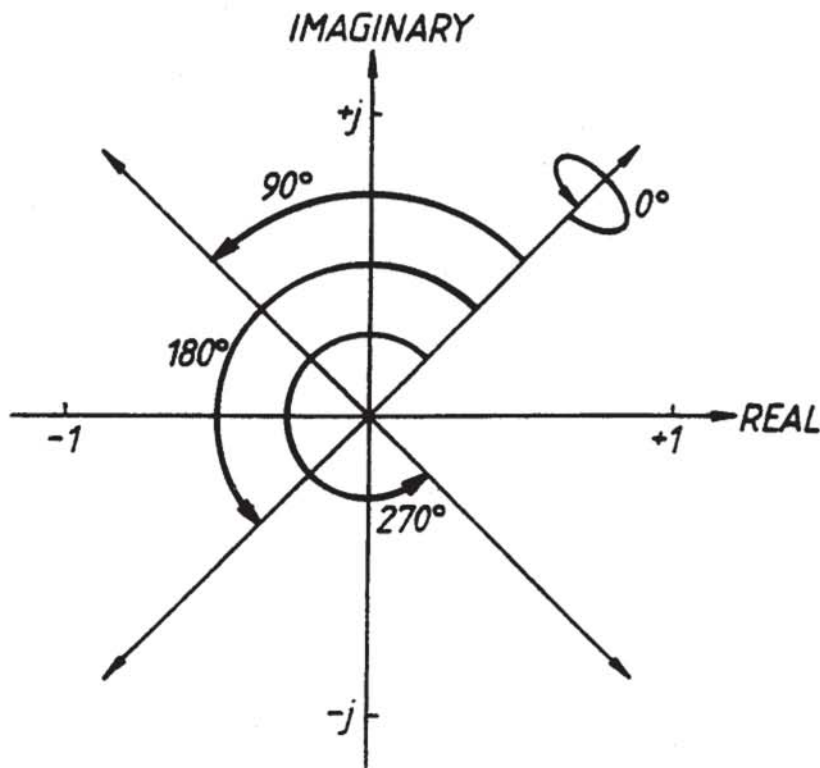


Fig 2C

| A ₃ | A ₂ | A ₁ | A ₀ | D ₁ | D ₀ |
|----------------|----------------|----------------|----------------|----------------|----------------|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 0 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 1 |
| 0 | 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 1 | 0 | 0 |

D₁D₀ CORRESPOND TO THE ALLOWED PHASE STATES AS FOLLOWS:

- 00 = +1+j
- 01 = +1-j
- 10 = -1+j
- 11 = -1-j

Fig. 2D
(PRIOR ART)

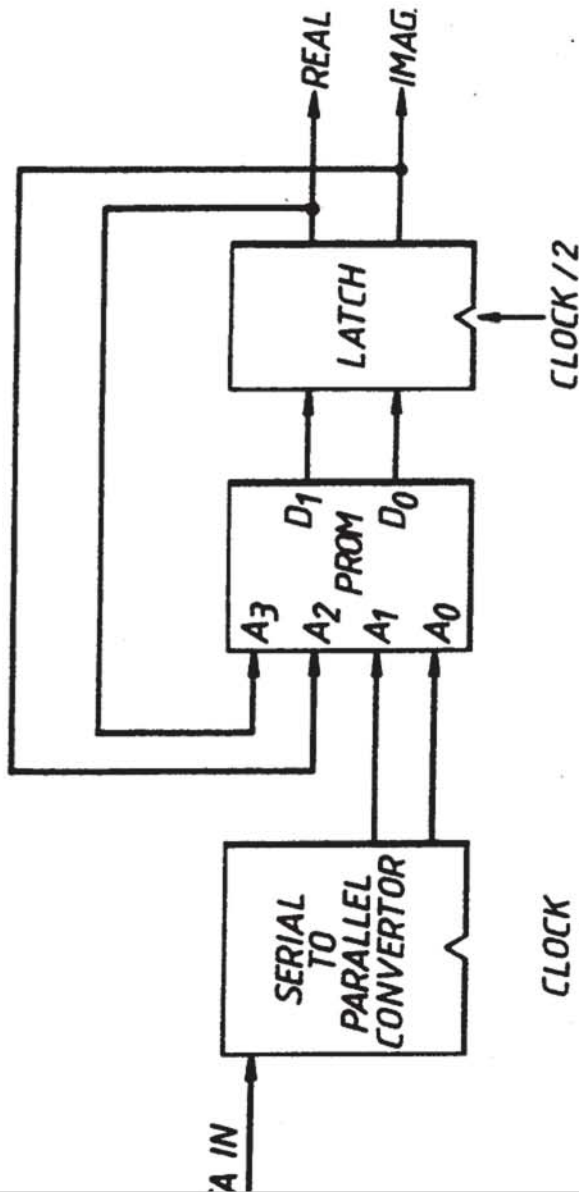
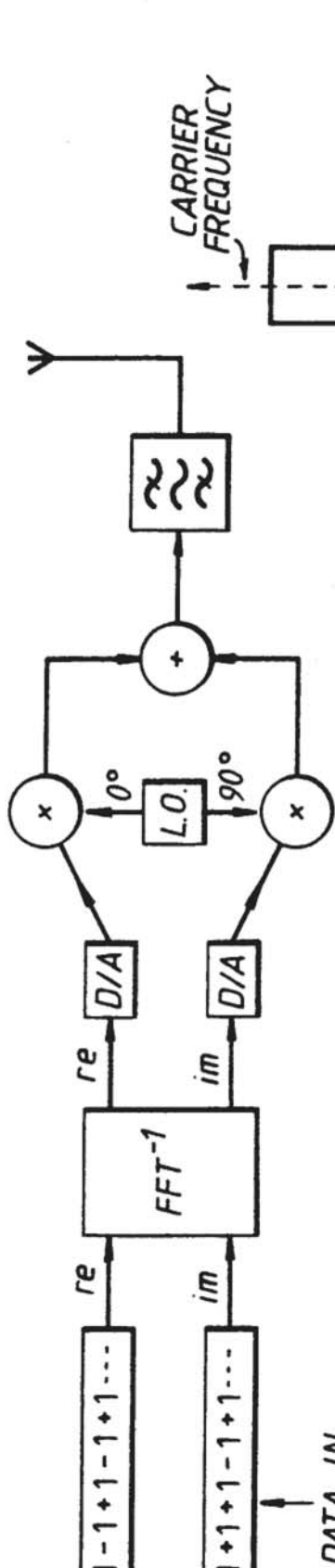


Fig. 2B
(PRIOR ART)



IQ METHOD

Fig. 3B

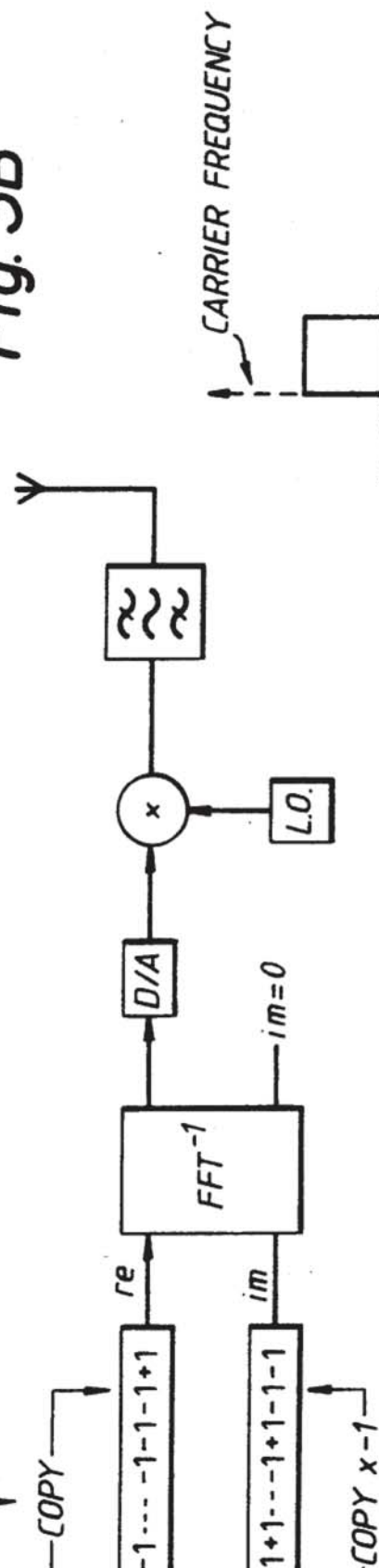


Fig. 3A

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