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APPLICATION OF ACOUSTOELECTRONIC DEVICES WITH REFLECTIVE ARRAYS TO SIGNAL PROCESSING

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1. Comparative characteristics of devices with reflective arrays and IDT

A typical SAW device with IDT is shown in Fig. 1. When an electrical signal is fed to the fingers of input IDT, a surface acoustic wave propagating to output IDT is excited due to the piezoeffect. In output IDT the acoustic wave is transformed into an electric signal. The layout of IDT fingers determines the transmission coefficient or pulse response of the device. In devices with reflective arrays (RA), surface or bulk

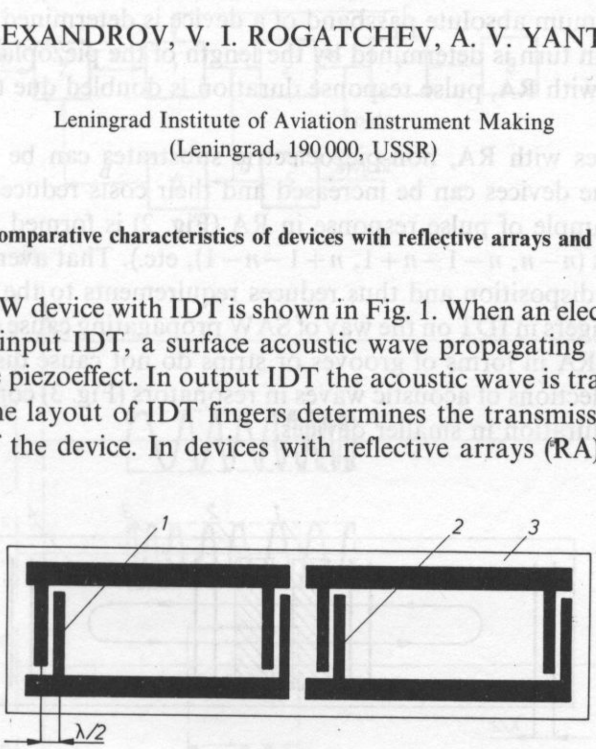

FIG. 1

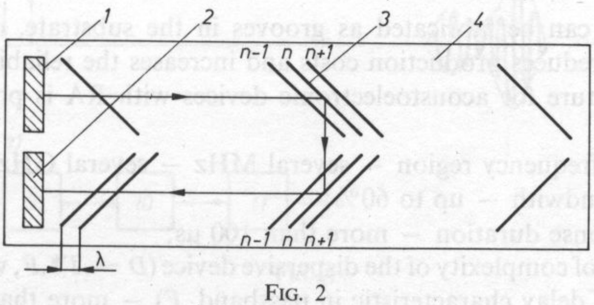

FIG. 2

waves are radiated and received with special transducers, and electrical characteristic are determined by the RA layout (Fig. 2).

A comparative analysis of acustoelectronic devices leads to the following conclusions:

– the distance between adjacent fingers in IDT is equal to $\lambda/2$ (where λ – acoustic wavelength), and the same distance in RA – λ. This make it possible to double operating frequencies with the same technological equipment.

– when IDT has defects (such as shorting or disconnections) the device is unsuitable. The same defects in RA do not affect device performance.

– the minimum absolute passband of a device is determined by pulse response duration which in turn is determined by the length of the piezoplate in a device with IDT. In devices with RA, pulse response duration is doubled due to the double path along the plate.

– in devices with RA, non-piezoelectric substrates can be used; in this way dimensions of the devices can be increased and their costs reduced.

– every sample of pulse response in RA (Fig. 2) is formed by interactions on several reflectors ($n-n$, $n-1-n+1$, $n+1-n-1$), etc.). That averages up all imperfections of their disposition and thus reduces requirements to the equipment [1].

– metal fingers in IDT on the way of SAW propagating cause dispertion or SAW wavefront shift. RA in forms of grooves or strips do not cause dispersion.

– multireflections of acoustic waves in resonators (Fig. 3) considerably increase pulse response duration in smaller devices.

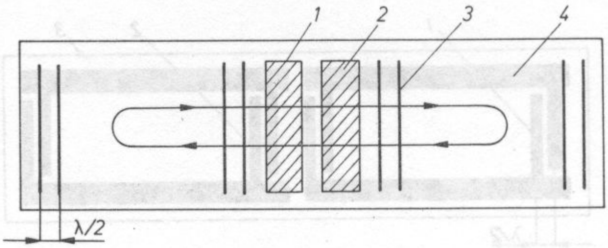

FIG. 3

– as RA can be fabricated as grooves in the substrate, metallization is not required. This reduces production costs and increases the reliability of devices.

A good future for acoustoelectronic devices with RA is proved by their high performance:

operating frequency region – several MHz – several GHz:

relative bandwith – up to 60%;

pulse response duration – more than 100 μs;

coefficient of complexity of the dispersive device ($D = .T^*.F$, where $.T$ – difference of the group delay characteristic in passband $.F$) – more than 10 000.

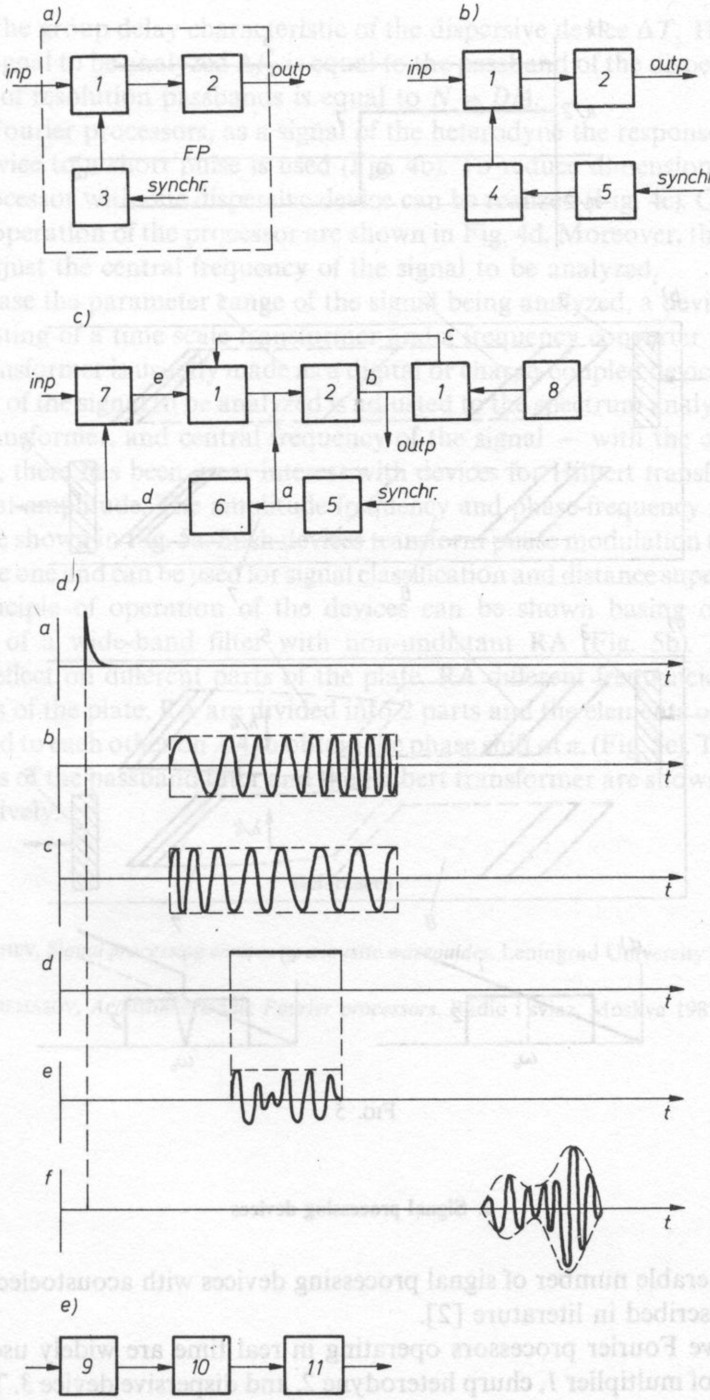

FIG. 4

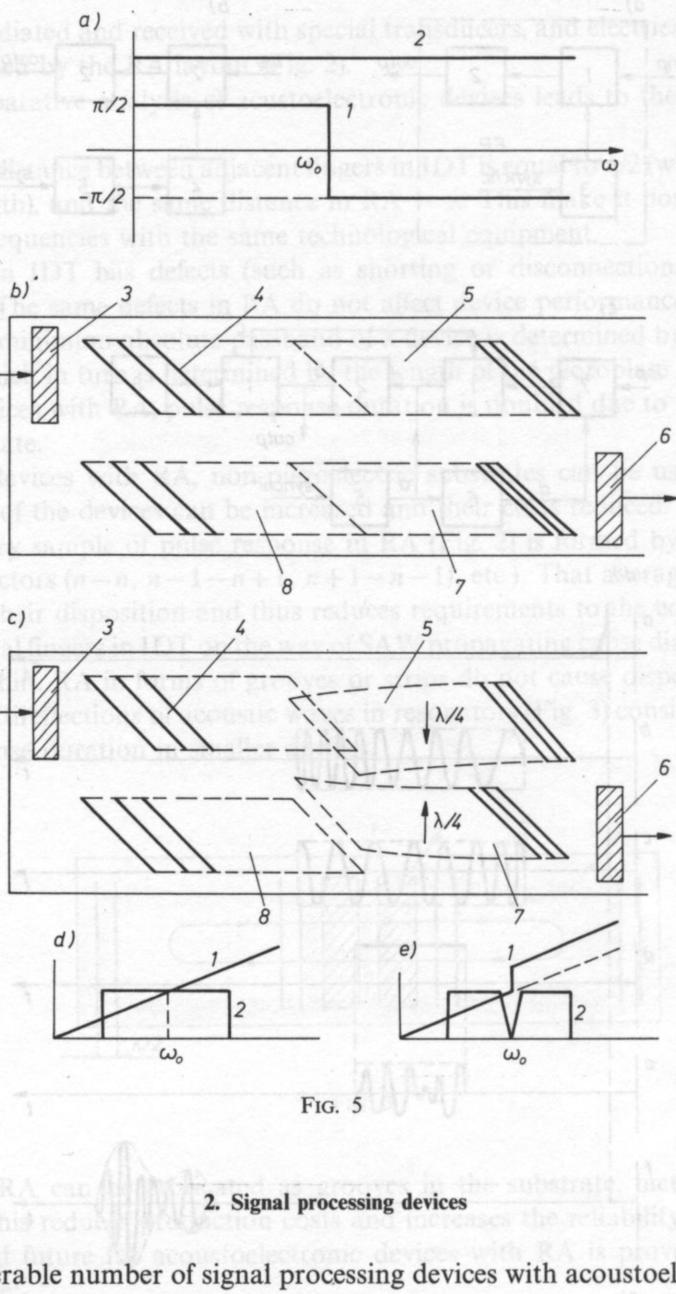

FIG. 5

2. Signal processing devices

A considerable number of signal processing devices with acoustoelectronic components is described in literature [2].

Dispersive Fourier processors operating in real time are widely used (Fig. 4a). They consist of multiplier *1*, churp heterodyne *2*, and dispersive device *3*. The parameters of the spectral analyzer are determined by those of the dispersive device. Frequency resolution $\delta f = 1/T_S$ is determined by sample duration T_S which is equal to half of the difference of the group delay characteristic of the dispersive device ΔT. The spectrum widthof the signal to be analyzed Δf_S is equal to the passband of the dispersive device. The number of resolution passbands is equal to $N = D/4$.

In real Fourier processors, as a signal of the heterodyne the response of another dispersive device to a short pulse is used (Fig. 4b). To reduce dimensions and costs, a Fourier processor with one dispersive device can be realized (Fig. 4c). Oscillograms showing the operation of the processor are shown in Fig. 4d. Moreover, this processor enables to adjust the central frequency of the signal to be analyzed.

To increase the parameter range of the signal being analyzed, a device shown in Fig. 4e consisting of a time scale transformer and a frequency converter is used. The time scale transformer is usually made as a digital or charge-coupled device [2]. In this case duration of the signal to be analyzed is adjusted to the spectrum analyzer with the time scale transformer, and central frequency of the signal – with the converter.

Recently, there has been great interest with devices for Hilbert transformation of complex signal amplitude. The amplitude frequency and phase-frequency responses of the devices are shown in Fig. 5a. Such devices transform phase modulation (phase hops) into amplitude one and can be used for signal classification and distance superresolution.

The principle of operation of the devices can be shown basing on a certain modification of a wide-band filter with non-undistant RA (Fig. 5b). As different frequencies reflect on different parts of the plate. RA different frequencies reflect on different parts of the plate, RA are divided into 2 parts and the elements of the second part are shifted to each other on $\lambda/4$ to obtain the phase shift of π. (Fig. 5c). The resulting characteristics of the passband filter and the Hilbert transformer are shown in Figs. 5d and e respectively.

References

[1] V. I. ROGATCHEV, *Signal processing devices on acoustic waveguides.* Leningrad University pb., Leningrad 1979.

[2] V. N. KOTCHEMASOV, *Acoustoelectronic Fourier processors*, Radio i sviaz, Moskva 1987.