Dec. 6, 1938. P. WARE 2,138,894

RADIO PAGING SYSTEM

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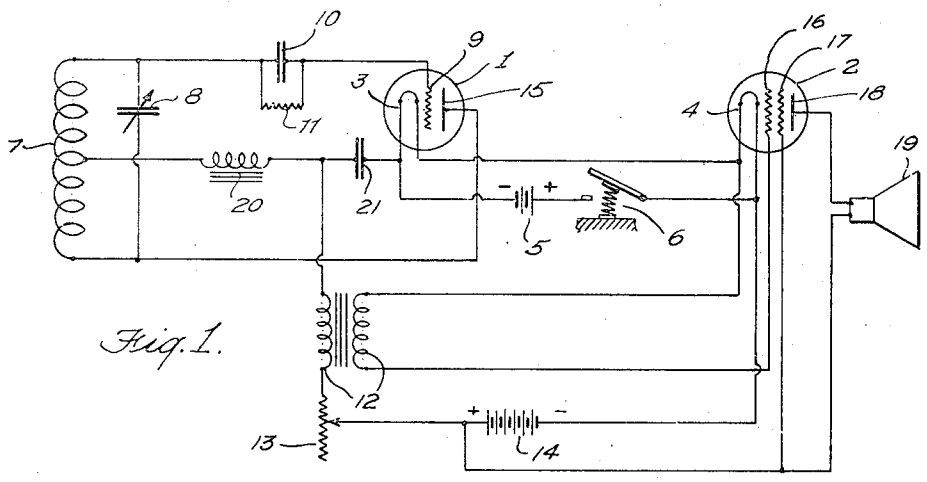

Fig. 1.

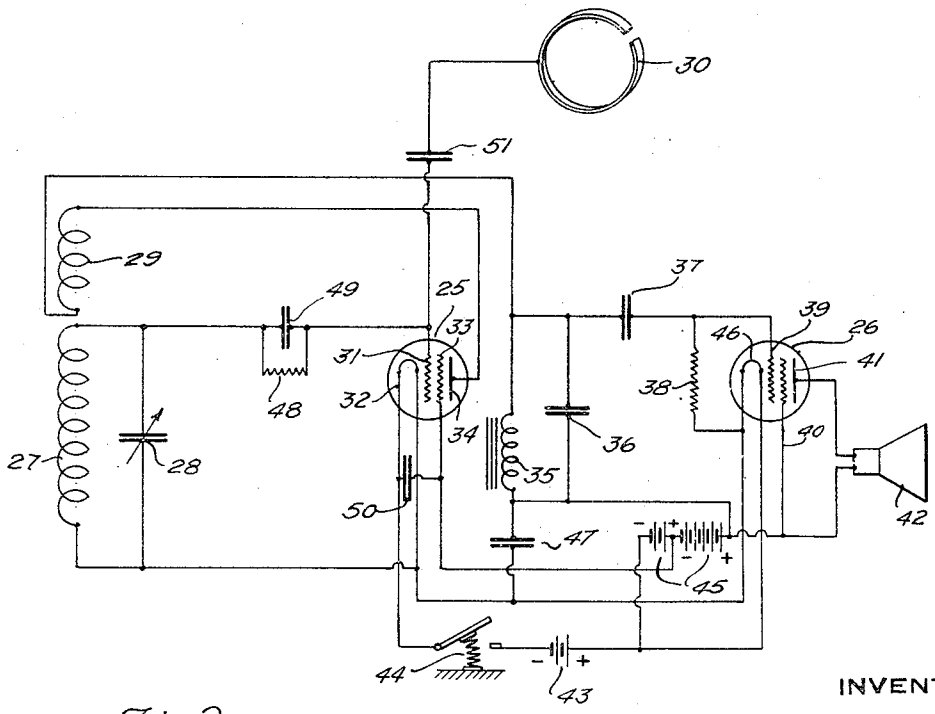

Fig. 2.

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Fig. 3.

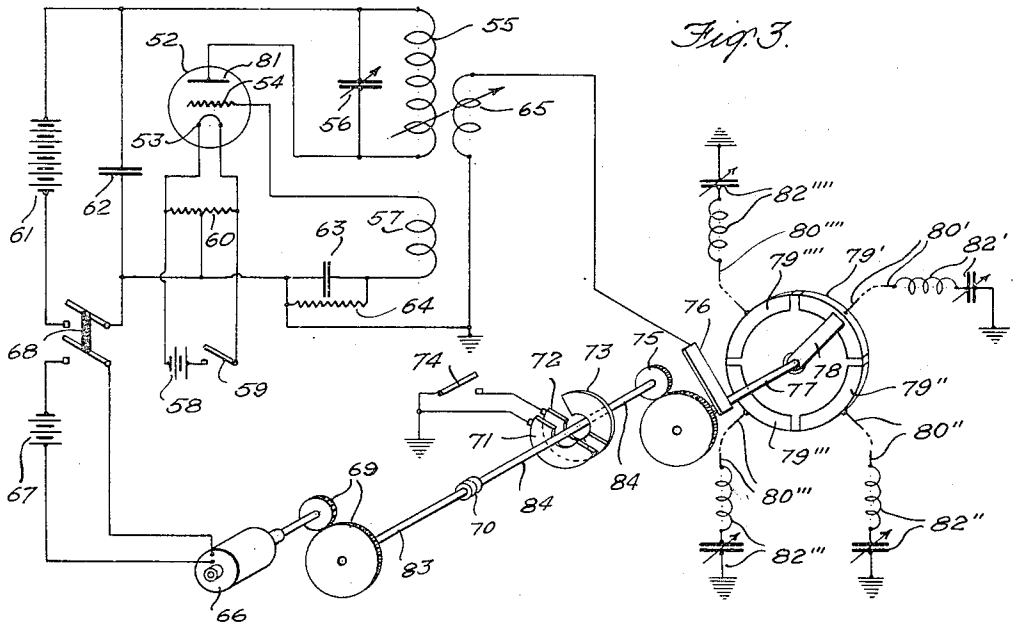
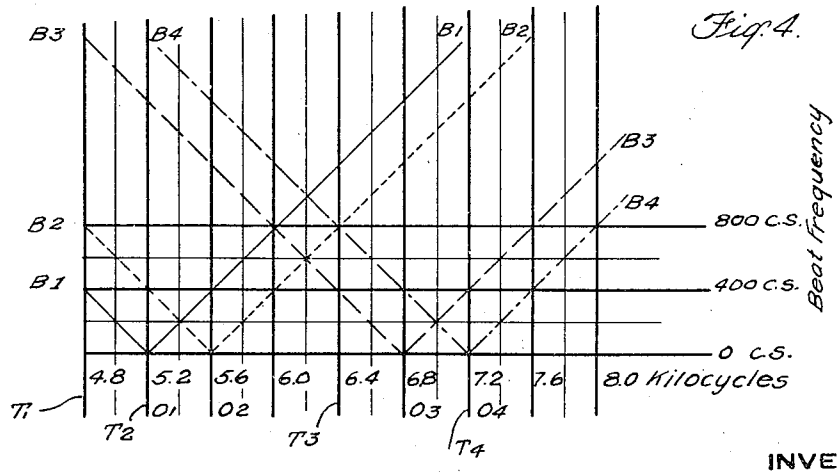


Fig. 4.



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RADIO PAGING SYSTEM

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5 Claims. (Cl. 250—2)

This invention relates to radio.

The invention provides novel means for the transmission and reception of radio frequency signals over comparatively short distances. One of the important fields of use is for calling or paging systems for hospitals whereby physicians and others in the hospital may be privately notified of calls or other matters. It will be understood however, that the invention is not limited to this particular use, but is capable of general application either in or out of doors for the transmission and reception of radio frequency signals. The invention is characterized by the use of low power and portability of receiving equipment to a degree where a complete receiving station may be carried in a person's pocket.

Two general systems are disclosed herein, one operating on a high radio frequency, above 30 megacycles, on one or more channels for prearranged modulated signals and the other a low radio frequency heterodyne system operating below 10 kilocycles on several channels, where calling is private due to selectively amplifying a beat frequency.

The invention will be understood from the following description considered in connection with the accompanying drawings forming a part thereof, and in which:

Fig. 1 is a diagrammatic illustration of a receiving station circuit for the high frequency system;

Fig. 2 is a diagrammatic illustration of a receiving station circuit for the low frequency system;

Fig. 3 is a diagrammatic illustration of a transmitting station circuit; and

Fig. 4 is a diagram illustrating the selectivity obtained with the low frequency system.

The high radio frequency system modulates a carrier with a tone in various prearranged signal combinations and receives the signals on a super-regenerative circuit with tuned audio amplification and loud speaking means of limited power. More than one carrier frequency may be used in an installation and the various receivers set with a fixed tuning adjustment to any one of such carriers. The carrier frequencies are preferably above 30 megacycles to enable efficient utilization of the super-regenerative receiving circuit, and also because the higher the frequency, the greater is the transmitting as well as the receiving efficiency of very small antenna structures. The transmitting equipment for this system is preferably of the usual master oscillator-power amplifier design capable of ready switching to one of several ultra high frequency channels. The transmitter is equipped with a power modulator arranged to produce a single pitch signal of two or three frequencies differing from each other by 100% or more, such as 400, 1000 and 2200 cycles per second, one frequency being sent out at a time.

Referring to Fig. 1 of the drawings which shows shows a preferred form of receiving station circuit for the high radio frequency system, reference character 1 designates a super-regenerator tube producing its own interrupter frequency in a conventional receiving circuit and 2 is a screen-grid audio amplifier tube. Filaments 3 and 4 in the tubes 1 and 2 respectively, are heated by A-battery 5 which is controlled by an on-off switch 6 preferably arranged so that when the receiving set which is enclosed in a small casing is dropped in the pocket of the person carrying the same, the switch thus will be closed but will be spring-pressed into open position, as shown, at all times when the set is not being carried in the pocket. The inductance 7 and capacity 8 form the resonant input circuit tunable to one of the aforementioned transmitting carriers. One side of this tuned circuit goes to control grid 9 of tube 1 by way of grid capacity 10 and grid leak 11, the plate 15 going to the other side of the tuned circuit. Greater power output is obtained with leak 11 connected as shown, but greater sensitivity is obtained if the leak is connected between grid 9 and filament 3. A tap off the tuned circuit goes to radio frequency choke 20 and thence to filament 3 by way of the by-pass capacity 21. At the joint between 20 and 21, a wire connects to the primary of an audio transformer 12, the secondary of which supplies the input terminals 16 and 4 of tube 2. Amplified audio signals pass from plate 18 to telephone receiver 19. Battery 14 supplies plate power for both tubes as well as for the screen-grid 17 of tube 2. High resistance rheostat 13 which is the sole adjustment available to the person carrying the set, is in series with the plate supply of tube 1 and functions to adjust the regeneration and is used as the volume control when desired.

The telephone receiver 19 is designed to have predominant natural frequency which roughly corresponds to one of the transmitter modulation signals instead of being made broadly responsive to all voice frequencies as in regular telephone practice. This resonant effect is aided by making tube 2 a high impedance screen grid tube. Also the audio transformer 12 is made

resonant at the natural frequency of the receiver 19. The degree of resonance of the audio transformer 12, that is the inductive reactance divided by the effective resistance for the signal frequency being amplified, is made as high as possible consistent with the very small size and weight permissible for the purpose for which it is intended. The size and weight limitation in this audio unit accounts for the wide difference in signal frequency used, as it is a requirement that the 400 and 2200 cycles per second signals be practically inaudible under all transmission conditions on a receiving unit equipped with a 1000 cycles per second resonant audio system. The super-regenerator interrupter frequency by-pass capacity 21 is also a part of the resonant audio transformer primary circuit. The constants of the receiving circuit are chosen so as to avoid interference between the interrupter frequency, and the signal frequency being amplified. Either a magnetic or a crystal type receiver may be used, the preference depending on the signal frequency to be amplified.

The great sensitivity of this receiving circuit and the high operating frequency make a receiving set aerial of more than a few inches hanging out of the pocket of the person carrying the set unnecessary where the invention is used in a paging system within a building. Even this small aerial is not needed in most locations. The low power transmitter may be fed into any existing wire or pipe system in the building, with places or regions in the building where reception is poor, that is, so-called "dead spots", being taken care of with antennas arranged and disposed as hereinafter described.

With the low radio frequency system, frequencies of the order of 10 kilocycles and less are employed which avoids interference with radio transmission. A number of private channels is possible but a receiving antenna is required due to the poor efficiency of small structures at the low frequencies at which this system operates.

Referring to Fig. 2 of the drawings, screen grid tubes 25 and 26 are the oscillating detector and audio amplifier tubes respectively. The resonant input circuit 27, 28 receives signals from an antenna 30, the character of which will be described more in detail hereinafter. A feed-back coil 29 placed between plate 34 and filament 32 by way of capacities 36 and 47, is inductively related to coil 27 to produce oscillations. A detector leak resistance 48 is by-passed by capacity 49. An iron core coil 35 resonates with capacity 36 to present high impedance to the output of tube 25 at some predetermined audio frequency. Capacity 37 blocks direct current but passes audio frequency signals to grid 39 of tube 26. Leak 38 which is connected to the negative side of filament 46 maintains grid 39 at the correct bias for the particular plate voltage used. The telephone receiver 42, of small design such as the Rochelle salt crystal or magnetic types, is connected between plate 41 and the positive terminal of B-battery 45, the negative of which is connected to the positive terminal of filament battery 43. The two filaments are in series and are controlled by an on-off switch 44 similar to the automatic switch 6 in Fig. 1. Screen grid 33, by-passed by capacity 50, is connected to a tap of battery 45. 47 is a by-pass capacity. The capacity 51 disposed in series with the antenna 30 functions to limit the maximum detuning of the input circuit 27, 28. Its value is preferably .00004 microfarad.

To overcome to a satisfactory degree the poor receptive efficiency of small structures on the low frequencies, a radio frequency connection to the skin is used, the small capacity between the receiving equipment as a whole and the skin of the person carrying the equipment, developing the source of voltage being received. The connection need not be a very good one as it is in series with the very small capacity and high resistance of the grid filament circuit of the first tube. A connection to a metallic wrist watch strap, or a light metal mesh arm band for summer use, or a small woven metal pad under the arm or against the side of the neck, is almost always satisfactory. A considerable difference in connection resistance is not noticeable. In special cases where the person using the equipment has inordinately dry skin, a better connection or pad of larger area is needed.

The operation of the receiving circuit shown in Fig. 2, is as follows: Incoming signals are approximately tuned by the circuit 27, 28 and are combined with local oscillations, the frequency of which is determined by 27, 28, by the detector action of tube 25. The beat frequency voltage thus developed across resistance 48 is then amplified by tube 25 in the output circuit of which is connected the high impedance beat resonator 35, 36. The beat frequency is further amplified by tube 26 and is heard from the telephone receiver or speaker 42.

The low frequency system has the advantage over the broad super-regenerative system of affording a number of private calling channels even though the calling carrier frequencies are spaced audible frequencies apart. This will be understood from an inspection of Fig. 4. A conservative case has been chosen where the resonated beat frequency receiver selectivity requirement is only plus or minus 100%. Assume there are four receiving sets with their oscillators fixedly adjusted to frequencies O_1, O_2, O_3, and O_4 respectively, on 5.2, 5.6, 6.8 and 7.2 kilocycles. The transmitting carrier is unmodulated, and if it is varied along the abscissas shown from 4.8 to 8.0 kilocycles, it will cause beats with the fixed oscillators corresponding to the curves designated B_1, B_2, B_3 and B_4. The ordinates are the beat frequencies produced, the heavy line at 400 cycles being the frequency at which all four receiver beat resonators are set. If now the transmitter is arranged to send a calling carrier on any one of the frequencies T_1, T_2, T_3 or T_4, it will be seen from Fig. 4 that if there is ample selectivity against signals plus or minus 100% off beat resonance, there will be no signal from the carrier on three of the frequencies if the receiving circuit is adjusted for the remaining frequency. As the diagram indicates, two private channels may be had in 1600 cycles, or eight in the range between 3,500 and 10,000 cycles. Obviously the sharper the resonance of the audio tuned circuit and the loud speaker, the greater the possible number of private channels.

The transmitting system for the low radio frequency system has certain novel features. Referring to Fig. 3, a power triode 52 has the usual grid 54, filament 53 and plate 81. The filament is heated by a source of power such as A-battery 58 which is in series with an on-off switch 59, and the resistance 60 is connected across 53 with its center tap grounded. Capacity 56 and inductance coil 55 control the frequency, with 57 the feed-back coil in the grid circuit. A "B" power supply 61 is in series with coil 55 and is

by-passed by capacity 62. The mutual winding directions of the coils 57 and 55 are such as to cause oscillations. Grid capacity 63 and resistance 64 are proportioned for best transmitting efficiency. Coupling coil 65 functions to transfer power through a brush 76 which rides on a rotating shaft 77, thence through a brush 78 which revolves inside of and successively makes contact with the segments 79', 79'', 79''', 79'''', and thence respectively to the separate antennas 80', 80'', 80''', 80''''.

Motor 66 is driven by source of power 67 in series with one pole of double pole-single throw switch 68, the other pole of which is in series with B-battery supply 61. The shaft of 66 operates a 10 to 1 gear pair 69 so that shaft 83 runs about 3 revolutions per second for a usual motor speed of 1800 R. P. M. Shaft 83 is coupled to shaft 84 by an insulating coupling 70. A 3 to 1 gear pair 75 further steps down the speed so that shaft 77 runs at approximately one revolution per second. The segments 79', 79'', 79''', 79'''', each occupy a little less than 90 degrees. The "wobbler" condenser comprising stator plates 71 and 72 which do not touch shaft 84, and rotor 73 attached to shaft 84 and clearing 71 and 72, functions to vary by a very small percentage the particular frequency being sent, to compensate for any slight error in receiving station oscillator setting assigned that particular transmitter frequency. The transmitter frequency settings are made mainly by capacity 56, but are also affected somewhat by the coupling between coils 57 and 55, also between coil 55 and capacity 56. Suitable meters, not shown because of their wide use in practice, may be utilized to indicate power input, power output and hence the efficiency of output.

As shown in Fig. 4 and the data pertaining thereto, one of eight different frequencies between 3,500 and 10,000 cycles per second may be transmitted privately to one of eight receiving stations such as shown in Fig. 2, with each station being adjusted for one of the eight frequencies, as hereinbefore described, without the other seven receiving stations receiving the signal. More than one receiver may be adjusted to receive any one of the eight transmitter frequencies.

The antennas 80', 80'', 80''', 80'''', are run through different parts of the building, when the invention is utilized indoors, and for a radiated power of 25 watts, may each be 500 to 1000 feet long and will give good calling signals at a distance of 25 feet from the wire. For a given radiated power, the signalling distance varies greatly with the type of structure encountered, the distances being great in the open and in wooden buildings, but diminishing greatly in steel frame buildings and especially where the antenna wire is run close to metal structures for long distances. The antenna tuning means 82', 82'', 82''', 82'''', aids transmission by increasing the transfer of power to the antennas at the very low frequencies used. The best adjustment is made on all antennas at or near the lowest transmitter frequencies as the efficiency is relatively poorer there.

A switch 74 is used for optionally grounding the stator plate 72. When plate 72 is grounded, the wobbler condenser increases its capacity range and thus becomes as effective on a low transmitter frequency as it is when the switch is open on a higher frequency. This is one of the adjustments made when the transmitter is quickly shifted from one of the fixed frequencies to another for calling. The other adjustments necessary, as hereinbefore mentioned, are that of capacity 56 and the coupling between coils 57, 55 and between coils 65, 55. As is customary in transmitter practice where it is desired to shift frequency quickly, all these adjustments are mechanically controlled by a shaft terminating in a manually turnable knob on the front of a panel with a pointer indicating the frequency setting on a visual scale. The filament switch 59 is usually left "on" continuously during operating hours. Signals are given by the closing of switch 68. A simple call will result from closing switch 68 for four seconds out of ten. This may be done manually or automatically by additional motor driven means. More than one signal may be sent out over a single frequency, such as a continual row of dots instead of a continuous "wobbled" carrier.

The frequency "wobbler" is unnecessary in the high frequency system because the super-regenerative receiving circuit is inherently broad enough to care for the variations in frequencies encountered. In the case of the low frequency system, however, the "wobbler" insures that the carrier wave will produce a beat note of proper frequency with the receiver oscillator at least part of the time, and hence produce a signal notwithstanding the combined maximum errors of the carrier and oscillator. This insures proper reception on small comparatively inexpensive receiving units which may not be capable of close adjustment. Such an arrangement contributes materially to the practicability of a system of simple cheap construction, and which is subjected to daily use by a large number of people, and by those who may not be familiar with electrical apparatus and its adjustment. The small resonant telephone receivers used as loud speakers give signals loud enough to be distinctly heard at several feet over ordinary noise levels of 40 decibels. The successive antenna switching arrangement may be applied to the high frequency method if it is needed due either to excessive distance requirements or to excessive shielding caused by accidental resonant structures encountered.

Thus it will be perceived that systems have been provided for the transmission and reception of radio frequency signals over comparatively short distances both at high radio frequencies and at low radio frequencies. The receiving sets diagrammatically illustrated in Figs. 1 and 2 may be contained in a casing or the like measuring as little at 3½ inches wide, 5 inches long and 1 inch thick, but it will be understood that if desired, these receiving sets may be enclosed in casings of smaller dimensions than these. With receiving sets of this size, they may be readily inserted in the pocket of a person desiring to carry the same and may be carried without inconvenience. By utilizing the invention for a hospital calling or paging system each physician or other person it is desired to call, upon entering the hospital will insert a receiving set in his pocket. When a certain physician or other person is to be called, radio signals are transmitted through the building and will be received only on the set carried by the person to be called unless of course more than one receiver has been assigned to the same frequency. The signal received will be audible to the person carrying the set so that he will be notified as soon as the signal is transmitted. The advantages of this arrange-

ment over the calling systems for hospitals now in use where lights are flashed in the corridors, or blaring loud speaker systems are utilized in the hospital will be obvious. As previously mentioned, the invention is not limited to hospital calling systems but may be used wherever it is desired to transmit and receive radio frequency signals over comparatively short distances.

Since changes may be made in the transmitting and receiving circuits herein disclosed without departing from the principles of the invention, it will be understood that no intention is entertained to limit the invention except by the scope of the appended claims.

What is claimed is:

1. A radio paging system comprising a transmitter having means for varying the frequency of the transmitted carrier, a plurality of portable radio receiving units each comprising an oscillating detector for producing a predetermined beat frequency with a carrier frequency to which said transmitter is adjustable and different beat frequencies with all other carrier frequencies, and a filter for passing currents of audible frequency produced by said predetermined beat frequency, means for amplifying said filter output, and means for indicating the presence of said output signal.

2. The combination of claim 1 wherein said last named means is a sound producing device designed to be resonant to the output signal.

3. A radio paging system comprising a wobble carrier frequency transmitter for transmitting any one of a plurality of wobbled frequencies a plurality of antennae arranged for individual connection to said transmitter, means for connecting said antennae to said transmitter in succession, and a plurality of portable radio receiving units each comprising a body embracing antenna, an oscillating detector connected to said antenna, an audio frequency filter for received signals, audio frequency amplifying means, and a receiver, said detectors each being tuned to produce a beat current of audible frequency with only one of said carrier frequencies.

4. A radio paging system comprising a transmitter having means for varying the frequency of the transmitted carrier, a plurality of portable radio receiving units of which one comprises an oscillating detector for producing a predetermined beat frequency within the audible range with a carrier frequency to which said transmitter is adjustable, another of said receivers comprising an oscillating detector tuned substantially to resonance with said carrier frequency, and still another of said receivers comprising an oscillating detector for producing a beat frequency of substantially twice the frequency of said first named predetermined beat frequency, a filter in each of said receivers connected to the detector therein for passing currents of audible frequency produced by said predetermined beat frequency, and means for audibly indicating the presence of an output signal from said filter.

5. A radio paging system comprising a transmitter having means for varying the frequency of the transmitted carrier, a plurality of portable receiving units each comprising an oscillating detector for producing a predetermined beat frequency with a carrier frequency to which said transmitter is adjustable and different beat frequencies with all other carrier frequencies from said transmitter, a filter for passing currents of audible frequency produced by said predetermined beat frequency, and means for indicating the presence of said audible frequency currents, said filter comprising a circuit tuned to resonance with said predetermined beat frequency and included in series in the output circuit of said detector.

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